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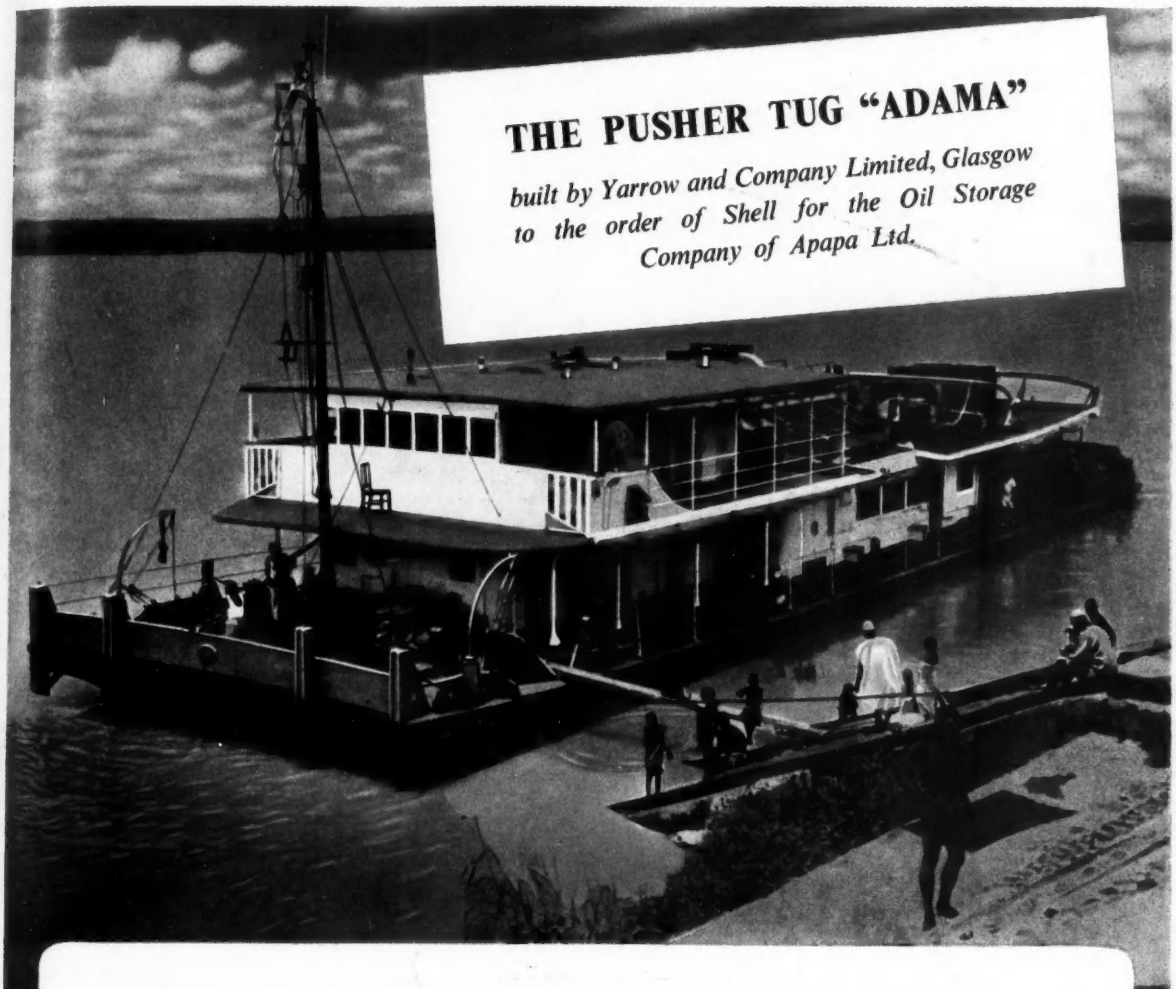
The Engineer

MARCH 20, 1953 28, ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS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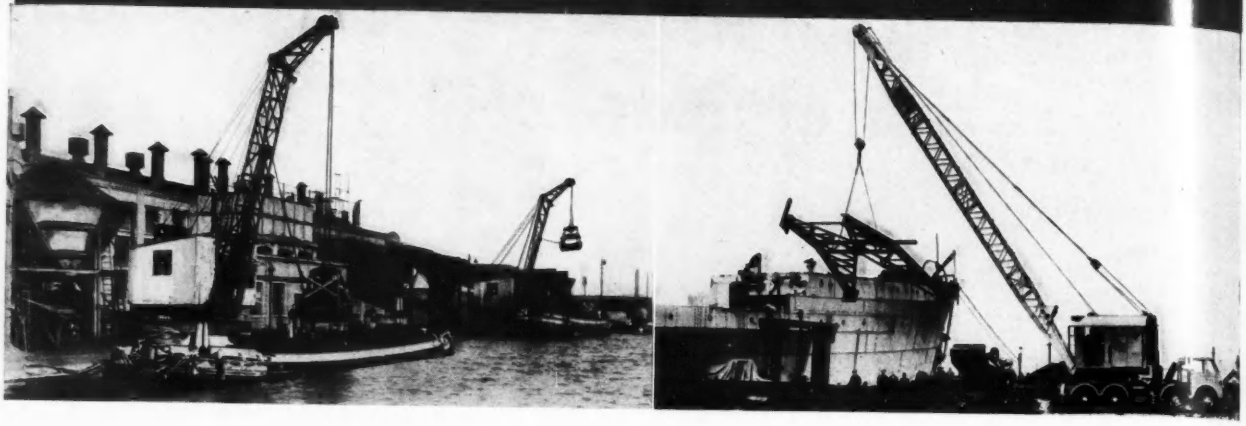

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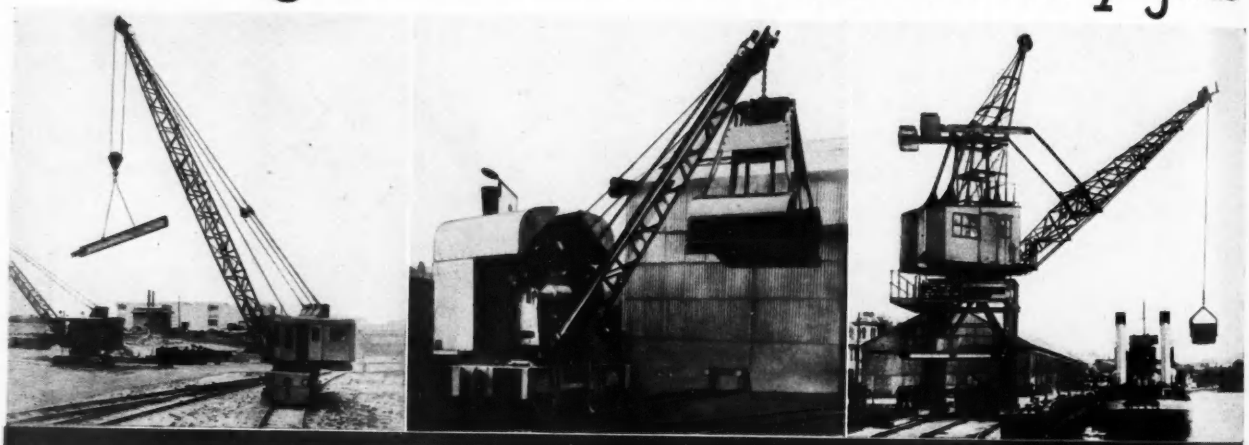

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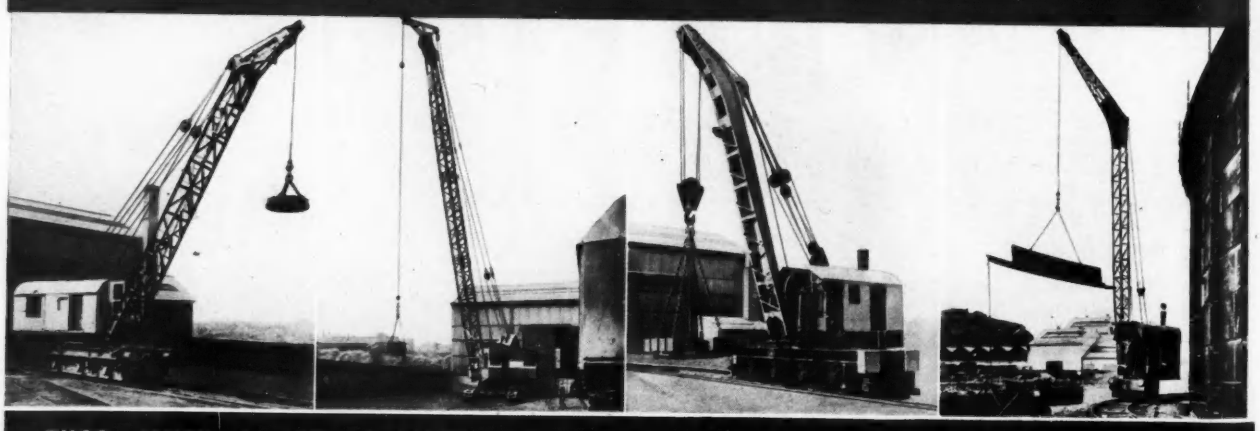

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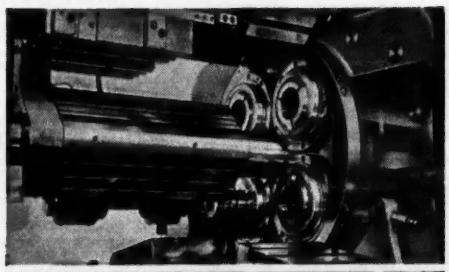
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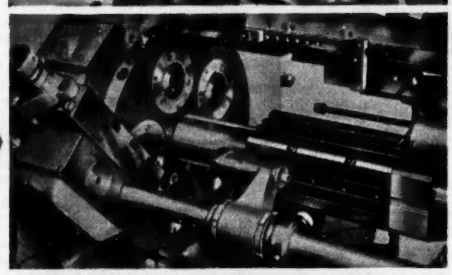
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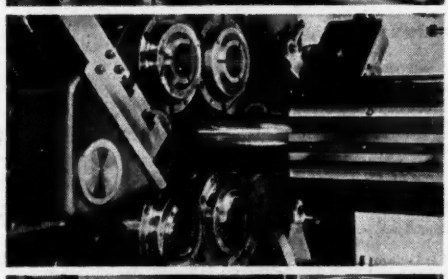
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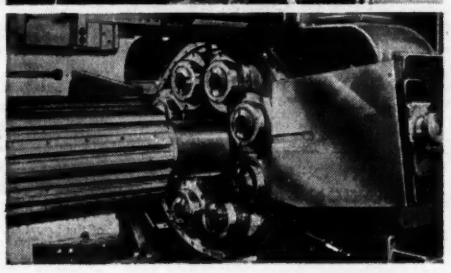
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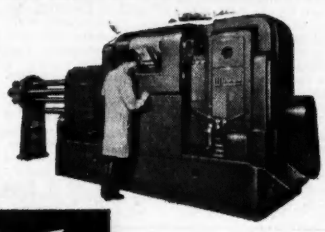

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WICKMAN of COVENTRY

WM280

THE ENGINEER

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PRINCIPAL CONTENTS

(Complete contents on page 426)

Engineers and Mathematics 426

Water Power in the Italian Alps—No. VI ... 410

Steels for Steam Power Plant 419

The Chesapeake Bay Bridge—No. II 417

Soil Failures in a Railway Cutting—No. II ... 414

The Newer Laminated Plastic Insulating Materials 436

The Development of a Marine Steam Turbine—No. II 439
(H. G. YATES)

The "Nomad" Compound Diesel Engine ... 422

NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

INDEX TO ADVERTISERS—PAGE 135

PUBLIC APPOINTMENTS

UNIVERSITY OF GLASGOW

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURESHIP

Applications are invited for a LECTURESHIP IN MECHANICAL ENGINEERING, with special reference to applied thermodynamics, tenable from 1st October, 1953, or such earlier date as may be arranged. The salary scale for the grading in question is £500 by £50 to £1100, but for a candidate with the experience and qualifications in view the commencing salary would be about £800.

There will be ample opportunity for the Lecturer to pursue research work.

F.S.S.U. and family allowance benefits.

Applications (six copies), including the names o three referees, should be lodged not later than 15th May, 1953, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.
E7763

UNIVERSITY OF SOUTHAMPTON

DEPARTMENT OF CIVIL ENGINEERING

LECTURER OR ASSISTANT LECTURER

Applications are invited for the post of LECTURER or ASSISTANT LECTURER tenable from 1st September, 1953. A good Honours Degree and practical or research experience in civil engineering hydraulics would be an advantage. Salary scales, Lecturer £550 by £50 to £1100, Assistant Lecturer £400 by £50 to £550, with F.S.S.U. and children's allowance benefits.—Further particulars may be obtained from the Secretary and Registrar, The University, Southampton. E7779

NORTHAMPTON POLYTECHNIC,

ST. JOHN STREET, LONDON, E.C.1

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

LECTURER IN CIVIL ENGINEERING

Applications are invited for the following appointment in the Civil and Me..hanical Engineering Department :—

LECTURER IN CIVIL ENGINEERING SUBJECTS, to be mainly concerned with the teaching of Civil Engineering Structures to Final Degree standard. Applicants should be suitably qualified, academically and by practical experience.

Salary £976 by £25 to £1088.

Further particulars and forms of application are obtainable from the Secretary, to whom applications should be sent not later than 10th April.

J. E. RICHARDSON,
Ph.D., B.Eng., M.I.E.E.,
Principal.
E7687

WOOLWICH POLYTECHNIC,

LONDON, S.E.18.

Principal : J. S. TAIT, Ph.D., B.Sc., A.R.T.C., M.I.E.E., A.M.I.Mech.E.

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

LECTURER AND ASSISTANTS, GRADE A

The Governing Body invite applications for the following posts :—

(i) LECTURER, preferably with a knowledge of structures and surveying up to standard of B.Sc. Engineering and Institution of Civil Engineers' examinations.

Candidates should have a good Honours Degree and practical experience.

(ii) ASSISTANT, Grade A, for mechanical and production engineering subjects. Candidates should have an Engineering Degree or equivalent qualification ; industrial experience is desirable, and they should state the subjects they prefer to teach.

(iii) ASSISTANT, Grade A, for machine shop engineering and motor vehicle work. It is desirable that candidates should possess an Engineering Degree, Higher National Certificate or similar qualification. Industrial experience is essential.

Salary scales : Lecturers, £940–£25–£1040 ; Assistant, Grade A, £415 to £784, according to qualifications and experience. All plus London allowance of £36 to £48.

Full particulars of the posts and application forms may be obtained from the Clerk to the Governors, to whom they should be returned not later than 10th April, 1953. E7810

COUNTY OF LEICESTER

EDUCATION COMMITTEE

COLLEGE OF FURTHER EDUCATION, LOUGHBOROUGH

LECTURER (GRADE B)

LECTURER (Grade B) in Engineering Workshop Practice required. Wide experience in engineering workshop practice essential. Full Technological Certificate in Engineering or similar qualification desirable.

Consideration given to registered disabled persons.

Memorandum of application obtainable from Director of Education, Grey Friars, Leicester. E7846

PUBLIC APPOINTMENTS

WOOLWICH POLYTECHNIC,

LONDON, S.E.18.

Principal : J. S. TAIT, Ph.D., B.Sc., A.R.T.C., M.I.E.E., A.M.I.Mech.E.

SECONDARY TECHNICAL SCHOOL IN ENGINEERING

ASSISTANT MASTER

The Governing Body invite applications for the appointment of an ASSISTANT MASTER to teach Workshop Practice. Candidates should be able to teach engineering drawing as well as metal work.

Salary according to the Primary and Secondary Schools Scale : qualified assistant teacher, £415–£18–£649–£21–£670, plus London allowance of £36–£48, and the following where applicable : (i) graduate allowance of £60, (ii) training allowance £18 for each year up to three for full-time study or training beyond two years, (iii) increments for industrial experience up to ten years, (iv) increments for full-time teaching experience.

Full particulars of the post and application forms may be obtained from the Clerk to the Governors, to whom they should be returned not later than 10th April, 1953. E7809

CORPORATION OF GLASGOW

EDUCATION DEPARTMENT

FURTHER EDUCATION

STOW COLLEGE, SCHOOL OF ENGINEERING

FULL-TIME TEACHERS

Applications are in..ted for posts for FULL-TIME TEACHERS of classes for the training of Marine Engineers for Ministry of Transport Certificates of Competency.

Applicants should hold the Extra First Class Engineer's Certificate of the Ministry of Transport or equivalent qualification and have not less than seven years' sea service, preferably on both steam and motor vessels. Teaching experience an advantage. Applicants who do not possess the Extra First Class Certificate but hold the First Class Certificate (Steam and Motor) and an appropriate technical qualification, such as the Higher National Certificate or Corporate Membership of the Institution of Mechanical or Electrical Engineers will be considered.

Successful applicants will be paid on varying scales ranging between £640 10s. per annum as a minimum and £900 per annum as a maximum, according to qualifications and subject meantime to an addition of £40 per annum. Placing will be given for approved full-time teaching experience.

Forms of application obtainable from the Director of Education, 129, Bath Street, Glasgow, C.2, to be returned not later than 11th April, 1953.

WILLIAM KERR,
Town Clerk.
E7803

SOUTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART

LONGBRIDGE ROAD, DAGENHAM

Principal : F. HEATHCOAT, M.Sc., Ph.D., F.R.I.C., F.I.M.

HEAD OF ENGINEERING DEPARTMENT

Applications invited for post of HEAD OF ENGINEERING DEPARTMENT (Burnham Report Grade III).

Salary : £1190 by £25 to £1340 (man), plus £36 or £48 London Allowance.

Applicants should possess a good Engineering Degree and have had suitable industrial, teaching and administrative experience. Further particulars and application form obtainable from the Chief Education Officer, County Offices, Chelmsford (stamped, addressed foolscap envelope), and returnable by 7th April. E7848

SCHOOL OF ELECTRONICS

ELECTRICAL ENGINEERING

SENIOR LECTURER OR LECTURER

Malvern, Worcs., School of Electronics requires SENIOR LECTURER or LECTURER to teach Electrical Engineering to O.N.C. and H.N.C. standards. Good knowledge of servo mechanisms required for A.2 year.

Degree or equivalent with teaching experience essential, industrial experience desirable.

Appointment will be graded Senior Lecturer or Lecturer according to successful candidate's qualifications. Salary on Burnham Scale for Technical Colleges with appropriate allowance for training, experience, &c., and subject to usual deductions for superannuation.

Details and forms from Principal, to whom completed forms must be returned within fourteen days of this notice. E7815

IMPERIAL COLLEGE

BURSARIES FOR POST-GRADUATE STUDENTS

BURSARIES are available for Session 1953–54 for Courses of Post-Graduate Study (not Research) in the following engineering subjects :—Civil (Hydraulics Structures and Materials, Soil Mechanics) ; Mechanical (Thermodynamics) ; Electrical (Communications, Electronics, Machines and Power) ; Chemical.

Applicants must have graduated at least one year before applying. Values of bursaries £300 p.a. to £400, according to circumstances.

Applications to Deputy Registrar, City and Guilds College, Exhibition Road, S.W.7, by 18th April, 1953. E7799

PUBLIC APPOINTMENTS

WARRINGTON EDUCATION COMMITTEE

WARRINGTON TECHNICAL COLLEGE

PRINCIPAL

Applications are invited for the post of PRINCIPAL, which will become vacant on 1st September, 1953. Candidates should have appropriate technical qualifications and adequate industrial and teaching experiences.

The present salary scale is £1000 by £25 to £1250, plus £40 special addition.

Forms of application and further particulars may be obtained from the undersigned upon receipt of a stamped, addressed, foolscap envelope, and should be returned within 14 days of the appearance of this advertisement.

H. M. PHILLIPSON,
Chief Education Officer.

Education Office,
Sankey Street,
Warrington. E7777

BRITISH ELECTRICITY AUTHORITY

SOUTHERN DIVISION

THIRD ASSISTANT ENGINEERS

Applications are invited for the following positions in the Construction Department :—

THIRD ASSISTANT ENGINEERS (Mechanical or Civil).

Mechanical Engineering : Applicants should have had experience in the design or construction of mechanical plant required in large engineering projects. Experience of generating station plant will be an advantage.

Civil Engineering : The work will include aspects of the construction of generating stations and applicants should have had experience of this or similar large engineering works.

JUNIOR ENGINEERS are also required for both the above sections.

Applicants for these positions should have had a sound technical education and training and should hold, or be obtaining, qualifications leading to Corporate Membership of an appropriate professional institution.

Salaries according to qualifications and experience : Third Assistants, £649–£835 ; Junior Engineers, £390–£556.

Special application forms are obtainable from P. D. A. Oliver, Esq., Divisional Secretary, British Electricity House, High Street, Portsmouth, and applicants should state for which position they wish to apply. The forms must be returned by 1st April, 1953. E7829

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS, ELECTRICITY AND LAND SURVEY DEPARTMENT

EXECUTIVE ENGINEER

Applications are invited for the following post :—

EXECUTIVE ENGINEER, Public Works, Electricity and Land Survey Department, Zanzibar.

Appointment on probation for permanent and pensionable employment with salary in the incremental scale £655 to £1320 per annum, plus a temporary variable non-pensionable cost-of-living allowance (maximum £250 p.a.).

Candidates, who should be under 35 years of age, must hold a recognised University Degree or Diploma in Civil Engineering, which carries exemption from Sections I and II of the A.M.I.C.E. examinations, plus two years' approved practical experience, or be A.M.I.C.E. Duties will include construction and maintenance of roads, airfields, buildings, water supplies, Drainage systems, &c.

Full details available on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number (CDE 112/10/01). E7819

MINISTRY OF LABOUR AND NATIONAL SERVICE

ELECTRICAL ENGINEERING ADVISER

The Commonwealth Relations Office invite applications for the post of ELECTRICAL ENGINEERING ADVISER in Ceylon under the Colombo Plan, to advise on the planning, construction and operation of hydro-electric and thermal power stations. Full professional qualifications and extensive experience in a commercial electricity supply undertaking, preferably in tropical country.

Salary £2000 per annum with a tax-free allowance of £1115 per annum for a married man (£613 if single). Free board and lodging, free medical attention, children's allowance if appropriate, return passage paid. Dependants' passages by negotiation.—Full details from Ministry of Labour and National Service, Almack House, 26/28, King Street, London, S.W.1, quoting A.12/CE 300/52. E7828

MIDDLETON HOSPITAL

FITTER

FITTER required, normal trade rate of pay. General engineering experience essential, including high and low steam pressure boilers, and pipe fitting hospital experience an advantage. House available on rental.—Written applications, giving details of qualifications and experience, to be sent to the Secretary, Middleton Hospital, Near Ilkley, not later than 31st March, 1953. E7781

PUBLIC APPOINTMENTS

HER MAJESTY'S COLONIA SERVICE

PUBLIC WORKS DEPARTMENT

MECHANICAL ENGINEERS

Applications are invited for the following p MECHANICAL ENGINEERS, Public Department, Malaya (CDE 112/60/08). Du to supervise and organise the staff and wo engaged in the assembly, erection, maintena repair of plant and machinery. The pla machinery includes diesel and steam road petrol and diesel-engined vehicles, air comp stone-crushing machinery, earth-moving equ diesel and steam pile-driving equipment, pu machinery.

Appointment is pensionable on probation contract for three years in the salary scale £1680 basic, point of entry depending on exp and war service plus a pensionable expat allowance varying from £266 to £364 p.a. In tion, there is a non-pensionable expatriation ance for married candidates varying from £259. A substantial variable cost-of-living all is also payable. In the case of a contract appoi a gratuity of £50 or £70 is payable for each com period of three months' service.

Free passages are provided once each tour for the officer, his wife and up to three under the age of 10. Furnished quarters, if av are provided at reasonable rents. Leave is at the rate of four days for each month of service.

Candidates, between the ages of 23 and 3 have passed or be exempt from Sections A an the examination for A.M.I.M.E. They should had at least three years' training in an engi works, drawing-office, machine shop, fitting foundry and pattern shop.

Two years' experience in a large engineering and a knowledge of the maintenance of and of earth-moving equipment would be an advan

Apply in writing to the Director of Recru Colonial Office, Great Smith Street, London, giving briefly age, qualifications and exp Mention the reference number (CDE 112/60/ E

NEW ZEALAND GOVERNME RAILWAYS

STRUCTURAL AND CIVIL ENGIN

Inquiries are invited from suitably qualified p to fill the undermentioned vacancies in New Z STRUCTURAL ENGINEERS (Ref. A.3/

Commencing salary : to be based on qualifi and experience. If possible all applicants have had some experience in regard to railway struction work.

CIVIL ENGINEERS (Ref. A.3/36/35).

Commencing salary : £605 (N.Z.) to £1030 according to qualifications and experience graduation.

Applicants should have had some experie railway civil engineers and would require to b Corporate Members of the Institution of Civil neers as soon as practicable after appointment already members. They would also require to b registered in New Zealand.

It is essential that the colour vision of all dates should be normal.

Further particulars, conditions of appoi and application forms may be obtained on r from the High Commissioner for New Zeala Strand, London, W.C.2, mentioning this pape quoting the reference appropriate to the vac given above.

The closing date for receiving completed a tions is 24th April, 1953. E

ESSEX RIVER BOARD

APPOINTMENT OF ASSISTANT ENGINEERS AND ENGINEERING ASSISTANTS

Applications are invited for posts of ASSIS ENGINEERS and ENGINEERING ASSIST within the Grades V to VII (£595–£785), accor qualifications and experience.

Applicants should preferably be Graduate o porate Members of the Institution of Civil Engi and practical experience in maritime or river wo be considered an advantage.

The appointments will be subject to the pro of the Local Government Superannuation Act.

Application forms may be obtained from should be completed and returned to the under as soon as possible and in no case later than April, 1953.

W. J. S. BEW,
Clerk of the Boa

Essex Rivers House,
Springfield Road,
Chelmsford, Essex.
10th March, 1953. E

WEST KENT MAIN SEWERA BOARD

JUNIOR ENGINEERING ASSISTA GRADE I

A vacancy exists for a JUNIOR ENGINEE ASSISTANT, Grade I (£465–£15×3–£510–L " weighting "). Applicants must have com articles or works training ; have at least one experience of general engineering drawing practice ; and be pursuing a recognised cou part-time study in civil engineering. Applicatio this appointment on forms obtainable from me be submitted by Tuesday, 31st March, 1953.

A. J. W. JEFFERY,
Secret

" Barnfield," 20, Blyth Road,
Bromley, Kent. E

THE ENGINEER

MARCH 20, 1953

Atmospheric Pollution in London

AT a meeting of the London County Council on Tuesday last, a report was submitted by the Rivers and Drainage Committee on the general question of atmospheric pollution in London. The report points out that, although the Council's powers in the matter are limited, it has from time to time made representations to the authorities concerned about smoke nuisance from electricity generating stations and the desirability of installing and maintaining efficient gas washing plant. For the past eight years, the report continues, a working group set up by the Department of Scientific and Industrial Research has been engaged on investigations with a view to finding less expensive and more satisfactory methods of removing sulphur compounds from flue gases. No reports which this working group may have presented have been made public and, in any event, its terms of reference do not touch upon the urgent and important questions of ascertaining the causes of atmospheric pollution and the formation of fog and their effect on health and property. The Rivers and Drainage Committee has therefore recommended the Council to ask the Ministers of Health, Housing and Local Government, and Fuel and Power to set up a committee of independent scientific and medical experts to inquire into atmospheric pollution and fog. The report suggests that this expert committee should be asked to advise on measures to protect health and property, and should also examine the general question of sulphur emissions from large coal burning installations, such as electricity generating stations, and particularly on the desirability of installing gas washing plants to reduce sulphur emissions.

Institute of Marine Engineers' Annual Dinner

THE fiftieth annual dinner of the Institute of Marine Engineers was held at Grosvenor House, Park Lane, London, on Friday last, March 13th, and was attended by over 1000 marine engineers and their guests, with Lord Howard de Walden, the president, in the chair. After honouring the loyal toasts, His Excellency M. Per Preben Prebensen the Norwegian Ambassador, gave the toast of "The Royal and Merchant Navies of the British Commonwealth." He referred to the Royal Navy as the sword and the Merchant Navy as the lifeline of Britain, and maintained that without the Merchant Navy the wide association of nations would never have been. Norway, he continued, which had a floating empire in its merchant fleet, had had an affinity with Britain since the Viking age. The Ambassador paid tribute to the technical contribution of British engineers and commented that Norwegian shipowners were the best customers of British shipyards. Admiral Sir Rhoderick McGrigor the First Sea Lord, replying to the toast recalled the war record of Norwegian ships, many of which sailed in the convoys under his command. He referred to the close association maintained between the Royal and Merchant Navies, and mentioned particularly the value of the training scheme in which naval officers served as supernumeraries in merchant ships. This country, Sir Rhoderick said, still depended upon its merchant shipping, and he viewed with concern the shrinking of our tonnage while world tonnage was expanding. It was essential to find money for ship replacement. But, Sir Rhoderick continued, there was a bright side, namely, the fertility in ideas of our scientists and engineers, although to maintain our standards more technical education facilities were required. In proposing the toast of "The Institute of Marine Engineers," Mr. Donald F. Anderson, president of the Chamber of Shipping and chairman of the Shipping Federation, praised the work of the Institute in helping in the training of young engineers, and emphasised the important role played by the engineer superintendents in the success of our merchant ships. Mr. Anderson went on to refer to the question of lightweight machinery and welcomed the lead given by the Admiralty, but felt that the commercial limitations were best understood by the Merchant Navy. Lord Howard de Walden, the president, in his reply, briefly mentioned the increasing membership of the Institute and the formation of local sections, and gave news of the new headquarters building.

Post-War Works of the Port of London Authority

THE extensive reconstruction work carried out since the war by the Port of London Authority formed the subject of a paper presented at the Institution of Civil Engineers on Tuesday, March 10th, by Mr. G. A. Wilson, and entitled "Port of London Authority Riverside Works, 1952." Mr. Wilson pointed out that in the period under review, the policy adopted had been, first, to repair, and, secondly, to reconstruct; consequently, although the work had been commercially important it had not been remarkable from an engineering point of view. Much of the work described in his paper was concerned with the reinstatement of dockside sheds, and with problems of layout for road and rail access and the provision of cranes. Amongst the extensive repair and reconstruction of dockside sheds, the work on sheds on the south side of the King George V dock may be given as an example of particular interest. Four sheds, 528ft long by 120ft wide, were raised 4ft 6in in height without dismantling, to enable goods to be stacked by mobile cranes to a new height of 14ft 6in. Eighteen screw jacks lifting 10 tons for 6in were used simultaneously on six rows of columns, the lift of 4ft 6in being accomplished in 252 lifts occupying four weeks. It was estimated that about £70,000 was saved by the use of this method as an alternative to providing new sheds. Mr. Wilson also described a small transit shed which was being built in prestressed concrete to ascertain the costs and advantages of this method of construction; aluminium sheeting had been similarly employed for the roof of a transit shed, he noted. The paper also commented on a number of mechanical engineering maintenance problems, including an experiment in dredger-ladder lubrication and the introduction of diesel-driven tugs. An interesting discussion followed the presentation of the paper, during the course of which various topics, such as the layout and operation of dockside facilities, were discussed at some length.

Speeding-up of Summer Train Services on British Railways

THE summer time tables announced by British Railways show that an appreciable number of main line trains are to be speeded-up on several important routes as a result of track improvements, and the smaller number of speed restrictions which will be imposed. On the Anglo-Scottish routes the principal day service between King's Cross and Edinburgh (Waverley), to be named "The Elizabethan," will cover the 392¾ miles in each direction non-stop in 6¾ h at an average speed of over 58 m.p.h., 22 min faster than last summer. Other long-distance expresses on the East Coast route, including the "Queen of Scots" Pullman, will be accelerated by from 5 min to 25 min. On the West Coast route the "Royal Scot" will leave both Euston and Glasgow (Central) at 10 a.m., as at present, but will be due at either terminus at 5.30 p.m., an acceleration of 30 min over last summer. Other important accelerations are also to be made on this route. Between London (Euston) and Birmingham five trains in each direction will cover the journey of 112¾ miles in 2 h, with one intermediate stop. On the West of England and South Wales routes to and from Paddington, two expresses will be accelerated to make start-to-stop runs at over 60 m.p.h.; seven trains will be speeded-up by from 10 min to 40 min, and five trains by up to 7 min. In the Southern Region the 10.8 a.m. Sandwich to Charing Cross and 4.15 p.m. return train will be accelerated by 3 min and 5 min respectively between Folkestone Central and Charing Cross, thus restoring the pre-war timing of 80 min for the distance of 71 miles, including a stop at Waterloo Junction. The services from Padstow and Bude by the "Atlantic Coast Express" will be accelerated by 36 min and 21 min respectively to Waterloo. A daytime Channel Islands service via Southampton is to be run in each direction on Sundays, leaving Waterloo at 9 a.m. and Jersey at 9.30 a.m., and the Dover-Ostend night service will this year run every night during July and August. Summer services will be in operation this year from June 8th to September 20th inclusive, and during this period, it is stated, the passenger trains in this country will cover some 4,350,000 miles weekly.

Car Parking in London

IN May, 1951, the Minister of Transport appointed a working party "to consider the recommendations made by the London and Home Counties Traffic Advisory Committee in regard to car parking in the inner area of London, and to formulate detailed proposals." Mr. A. Samuels, A.M.I.Mech.E., chairman of the London and Home Counties Traffic Advisory Committee, acted as chairman of the working party. Its report to the Minister of Transport was published at the end of last week by H.M. Stationery Office. The report contains four main proposals designed to ease the congestion on the streets of London caused by standing vehicles. These proposals are being put forward as essential parts of what the working party describes as a parking plan for Central London. The first proposal is the construction of garages beneath some London squares and in suitable places on normal building sites. The other parts of the plan would be carried out as these garages are completed and would be confined to within a quarter of a mile of each garage. Proposals for them include the introduction of parking meters in street parking places for motorists wishing to leave their cars for not more than two hours, the extension of unilateral waiting to all streets of minor through-traffic importance for motorists calling at shops or other buildings in the neighbourhood, and the extension of "no waiting" in the main streets. In its report, the working party has made some detailed recommendations as to the way in which it is considered the plan can best be implemented. The first suggestion is that a start should be made with the construction of garages under Grosvenor Square, Berkeley Square, Cavendish Square, and St. James's Square. As to the financial arrangements, the working party recommends that these underground garages should be built by the Government for lease either to the local authority concerned or to a suitable private firm, the rent in each case to be such that the garages could be operated as an economic trading venture. As part of its investigation, the working party made a census in Central London of all vehicles parked in the streets, in all "off-street" parking places and in garages. The results showed that about 16,000 vehicles were parked each day for long periods in the streets, and that the total "off-street" accommodation fell short of what was needed by about 12,000 car spaces.

Water Power in the Italian Alps

No. VI—(*Continued from page 376, March 13th*)

Some examples of industrial power stations in Northern Italy are given here, the developments described belonging to the Montecatini Group of companies and the Falck Iron and Steel Company. They provide examples of recent underground power station design, a transmission line built at high altitudes, and of early multiple arch, cupola and gravity buttress dams.

APART from the public supply companies, a number of Italian firms which consume large quantities of power also participate in the construction and operation of hydro-electric power stations. One such group of companies is the Montecatini organisation, which is the largest Italian mining and chemical concern. Its activities include a number of processes, such as the extraction of aluminium to give only one example, in which the cost of electrical power is of principal importance. The Montecatini Group has therefore constructed a number of power stations, employing both thermal and water power, and has built a system of high-tension transmission lines. The Group has its own staff for the design and construction of hydro-electric power stations.

The Montecatini Group's hydro-electric schemes are situated on the Upper Adige, and in the catchment of its tributary the Isarco. Two early examples of the recent Italian trend in underground power stations are the schemes at Ponte Gardena, on the Isarco, and the Bressanone development, which utilises both the Isarco and the Rienza. These two schemes were built between 1937 and 1941. The Bressanone development has intakes from reservoirs on both the streams mentioned above, the one on the Isarco being formed by an arch dam, 64m high, leading to a single diversion tunnel, 6000m in length and 5·2m in diameter. This tunnel ends in a combined forebay and surge chamber of complicated configuration, which has a capacity of 10,000 cubic metres. A single reinforced concrete penstock with a diameter of about 6m and a length of 350m, constructed solid with the surrounding rock, leads from this chamber to the power station. The turbo-alternator room is a chamber 105m long and 16·5m wide, with an access tunnel 60m long. It contains three 37·5MVA and two 18·75MVA turbo-alternator sets, all five being driven by vertical Francis turbines. The gross head is 164m, the catchment area 2700 square kilometres, the flow at full rated load 80 cumecs, and the average annual production of power 550 million kWh. A subsidiary power station, below this one, which forms part of the scheme, produces another 30 million kWh.

Castelbello and Glorenza

The Montecatini Group's most recent hydro-electric developments are, however, situated on the Upper Adige. Near the source of the river a seasonal reservoir—S. Valentino—with a storage capacity of 110 million cubic metres (nearly 90,000 acre-feet) has been formed at a level of about 1500m above sea level. This storage is equivalent to a production of 150 million kWh at Glorenza power station. Diversion works lead from this reservoir to Glorenza power station, from whence the diverted waters are returned to the Adige. A barrage across the river still further downstream forms the intake of the Castelbello power station. The accompanying table gives the principal data for these two power stations.

	Glorenza	Castelbello
Annual production, kWh × 10^6	235	400
Installed capacity, MVA	116	90
Gross head, metres	595	294
Maximum flow, cumecs	18	30

S. Valentino reservoir is unusual, in that it is formed by an earth dam, 32·5m in height. This dam is the first of its kind to be built in Italy by modern earth-moving plant and was the subject of considerable study, a site laboratory for soil mechanics testing being set up whilst construction was in progress. It is the largest earth dam in Italy, its volume being about 600,000 cubic metres. The impervious core of the dam is of clay and bentonite (the latter being a mineral obtained from near Naples). Eight bell-

Fig. 35—Castelbello Underground Power Station

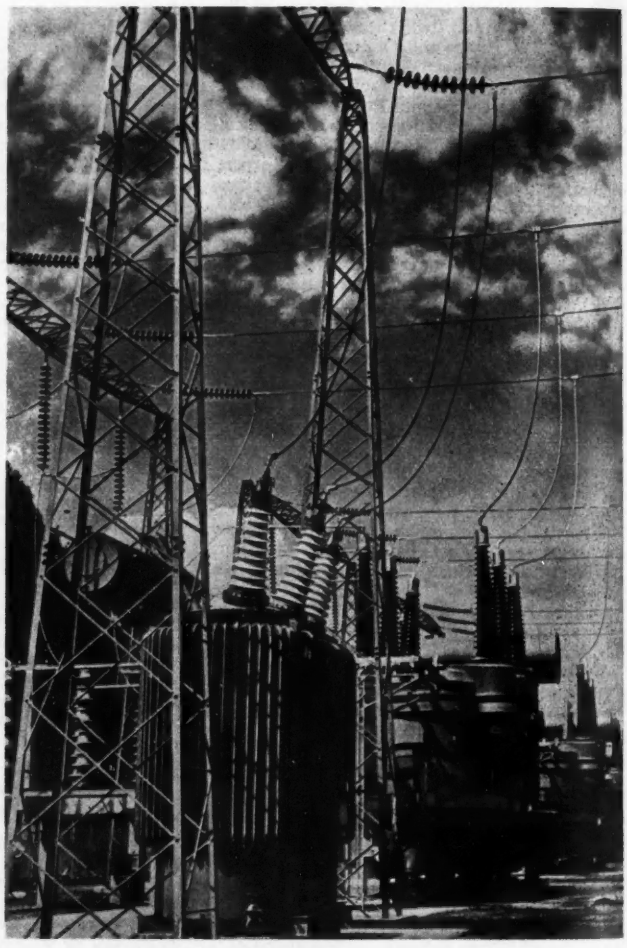


Fig. 36—Switching Station at Castelbello

Fig. 37—220kV Transmission Line Tower on Stelvio Pass

Fig. 38—Belviso Power Station

mouthed spillways have been built close to the dam; provision has been made for raising the dam and spillways by 6m at a later date, should this measure prove necessary. A scour pipe and valve tower and, close to it, the intake works for the diversion tunnel have been built on the right bank of the reservoir near the spillways. The reservoir is on the site of two natural lakes, and there is also a lake downstream of the dam. A pumping station has been built so that the tunnel to Glorenza power station can be supplied from this lake as well as from the reservoir when it is required to conserve the reservoir water as much as possible.

One of the problems of this development was the presence in the reservoir of floating islands of vegetable material; it was thought that, should certain wind conditions occur when the reservoir was spilling, one of the islands might foul the spillways. The method adopted so far has been to sink the islands wherever possible by placing rocks on them and of anchoring the larger ones to the banks with ropes.

The construction of this reservoir has entailed the building of a new village to replace the dwellings which have been submerged.

A pressure tunnel of circular cross section. 3m in diameter, leads from the intake works of the S. Valentino's reservoir to the surge chamber near the power station. This tunnel is about 12km in length and has a capacity of 20 cumecs. Near the reservoir the tunnel has a subsidiary intake from the pumping station, as mentioned earlier, and also a connection to the Adige, which may be used to empty the reservoir, as well as the normal scour pipe. There are also two side stream intakes, the second one leading into the surge chambers. The latter consist of a horizontal expansion chamber at the tunnel level, and an inclined shaft of large diameter leading up to a second similar horizontal expansion chamber. An inclined shaft of smaller diameter leads up to the rock surface from the upper junction. There is a valve chamber just downstream of the surge chambers, at the head of the penstock, which consists of a single welded steel pipe, laid in a tunnel. The penstock diameter varies from 2·5m to 2·1m and it is reinforced with shrunk-on steel bands in the lower part.

There are two 58MVA horizontal turbo-alternators sets in the power station, each consisting of an alternator driven by two Pelton wheels. These sets were originally ordered from Germany before the war, but only one was delivered in time to be installed in the power station. The Italian set which was substituted has a shaft in three sections, coupled between the alternator and each Pelton wheel. The German design, however, embodies a single shaft with two bearings and the Pelton wheels overhung. It is understood that it was not possible to forge a shaft of such magnitude with Italian plant. On completion of the power station the second turbo-alternator set was delivered and is now kept, stored in an air-conditioned enclosure, at Glorenza. Further developments are envisaged on various right bank tributaries of the Adige between Castelbello and Glorenza, and one of the new power stations is to be designed so that this 58MVA set can be installed in it. This somewhat unusual procedure gives an example of one of the many difficulties which have had to be faced by the Montecatini Group in its very extensive post-war reconstruction.

The access tunnel to Glorenza power station is about 500m in length. The transformers are situated in a chamber near the mouth of this tunnel, and the busbars from the machines are brought to them in a separate tunnel; to minimise power losses in the 500m length of this tunnel the busbars have been arranged in delta form. Remote control of the turbo-alternator sets is provided in a control room in the building at the tunnel entrance, but duplicate controls have also been provided in the machine hall, which were used until experience with the remote control installation had been gained.

The tail-race from Glorenza power station leads back into the River Adige, forming an open channel for the last part of its length. As the valley is fairly wide here a reservoir of 270,000 cubic metres capacity has been built, to provide pondage for the operation of Castelbello power station.

Eight kilometres below the tail-race of Glorenza power station there is a barrage across the Adige, with sluice gates controlling the flow diverted to Castelbello power station. The diverted flow passes first through sand removal channels and then into a tunnel 4m in diameter and 17·4km long. Pondage is provided by a storage basin of 22,000 cubic metres capacity in the valley close to the intake. This was the maximum capacity which the configuration of the valley allowed, so that a further 22,000 cubic metres of storage is provided in a chamber excavated along the line of the tunnel. These two basins give sufficient pondage to take up the minor variations in flow, as water released from the reservoir at

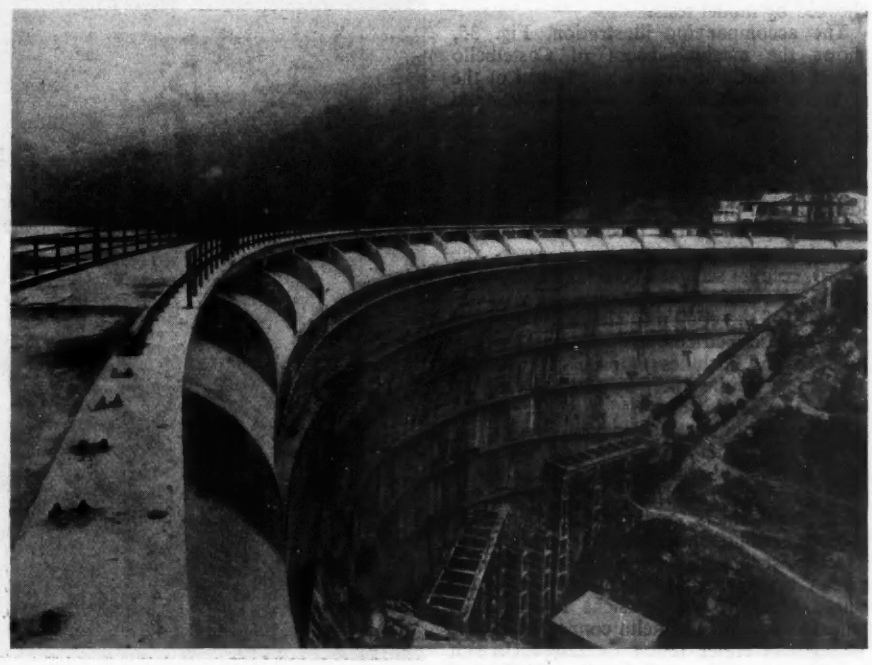


Fig. 39—Osiglietta Dam

Fig. 40—Belviso Power Station

Glorenza, mentioned above, takes about an hour to reach this point.

The diversion tunnel ends in a complicated surge chamber installation, in which the expansion chamber has a volume of 10,000 cubic metres. The penstock is of reinforced concrete and is cast solid with the surrounding rock; its diameter varies from 3·6m to 3·3m. The principal chamber of the power station is 54·5m by 13·5m in plan, and there are three 30MVA vertical Francis turbo-alternator sets installed. The transformers are in the open air. It may be noted that the head of 294m is a high one for the use of Francis turbines (the power station was completed in 1949), and an interesting comparison may be made with the Loch Sloy power station,* where the head is about the same and the installed capacity a little larger. The designs of the surge chamber and of the penstock at Castelbello were checked by model tests.

The accompanying illustration, Fig. 35, shows the machine room of Castelbello power station, and gives a good ideal of the style of architecture which has been developed for the Italian underground power station. The lighting is grouped into "windows," thus avoiding glare and giving the illusion of being in a normal surface building; the lower part of the walls are faced with marble, in which green is the predominant colour, and the alternators are painted green, the entire colour scheme being pleasing and restful.

Much of the equipment in the two power stations described here is of the latest Italian practice and includes amongst the control apparatus, for instance, flow integrators, by which the total quantity of water passed through the power station can be checked against the units generated. Such instruments had not, we understand, been generally used previously in Italian power stations. The transformers and switching stations include various refinements of earlier Italian practice, such as the use of small oil volume circuit breakers and switches giving single-phase reclosure of transient faults. The transformers are star-delta connected to give voltages of either 130kV or 220kV (to suit existing or new transmission lines at the two voltages respectively). The transformers and part of the switching station at Castelbello power station are shown in Fig. 36.

The Montecatini Group's transmission lines include a 220kV line which has recently been built to take the power from Castelbello and Glorenza to the Group's centres of consumption at Cesano Moderna and Novara. This line passes over Stelvio Pass, at a maximum elevation of 2900m. This part of the line presented exceptionally difficult problems on account of its high altitude and the ruggedness of the terrain. One of the towers of the line at Stelvio pass is shown in Fig. 37. The line is carried on welded tubular high-tensile steel towers, proportioned to give the minimum possible structural weight, as shown in the illustration. A continuous uninterrupted service was aimed at in the design of this transmission line, whilst making it as economical as possible, and the use of forked pylons, with the three power lines disposed in the same horizontal plane, was chosen as the most satisfactory arrangement. One of the principal factors in choosing the location of the line over Stelvio Pass was that of positioning the towers where they would be least susceptible to damage from avalanches. In some cases protective concrete walls have been built at the bases of the towers, but the chief precaution has been that of siting them at places such as local "peaks" of rock, where an avalanche of any magnitude is unlikely. Damage to transmission lines due to avalanches occurs regularly in the Alps and may be serious. Up to the present this line over Stelvio Pass has had an exceptionally good record in this respect.

The line carries 120,000kW, for which the normal conductor used is in aluminium and steel, with thirty aluminium wires formed on a steel core of nineteen wires, of the dimensions shown in the table.

	Diameter, mm	Total area, sq. mm
Aluminium wires	3·85	349·25
Steel wires	2·30	78·94
Total		428·19

The conductor has a diameter of 26·9mm, corresponding to a copper conductivity of 218·5 square millimetres. The average insulation for the zones which are not at great altitude consists of strings of sixteen insulators in chain (with a breaking load of 6000kg), with eighteen insulators (breaking load 10,000kg) at the terminal position. This insulation is increased, from both the physical and mechanical points of view, in the mountain areas. There are one or two lightning conductors to earth on each pylon, made of galvanised high-tensile steel.

This 220kV line is connected to the principal lines of the public supply companies and has been used for the import and export of power for public consumption. During the winter of 1950–51, the first winter that the line was in operation, power was imported to Italy by transmission lines across Germany and Austria and thence by this line.

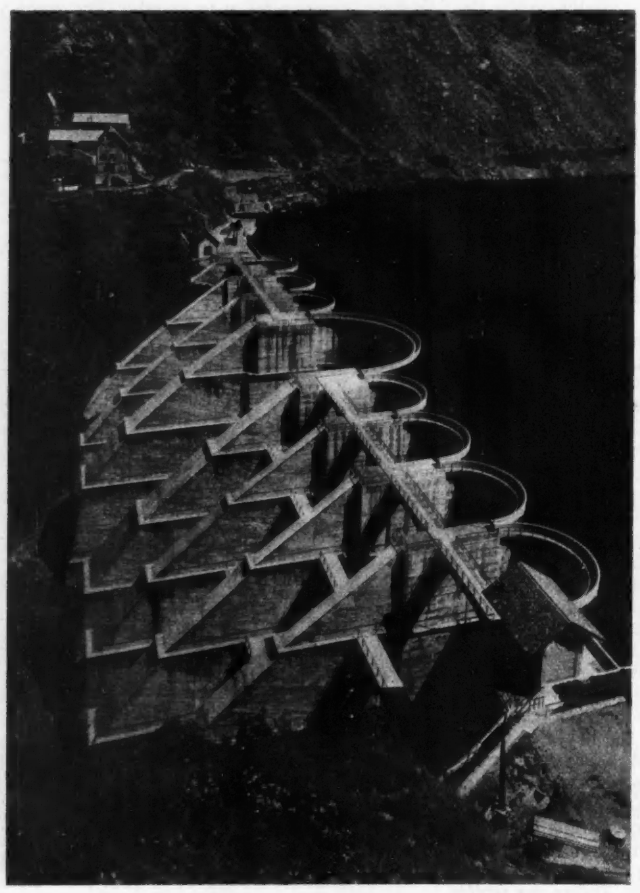


Fig. 41—Lago Venina Dam

The Falck Iron and Steel Company

Another industrial concern which carries out its own generation of power on a large scale is the Acciaierie e Ferriere Lombarde Falck, an iron and steel company. Amongst the hydro-electric schemes which this company owns is one in the Bormida catchment in the Ligurian Alps, near Savona. The principal reservoir of this scheme is formed by a cupola dam—the Osiglietta dam—with a pronounced downstream overhang, which was built in the years 1937–39, and is thus probably the first dam of this kind. It is 76m in height and is shown in Fig. 39. The company also operates hydro-electric schemes in Tuscany, on the Magra River, but its most important source of power is in the catchment of the Adda river in the area known as

* See The Engineer, July 21–August 4, 1950.

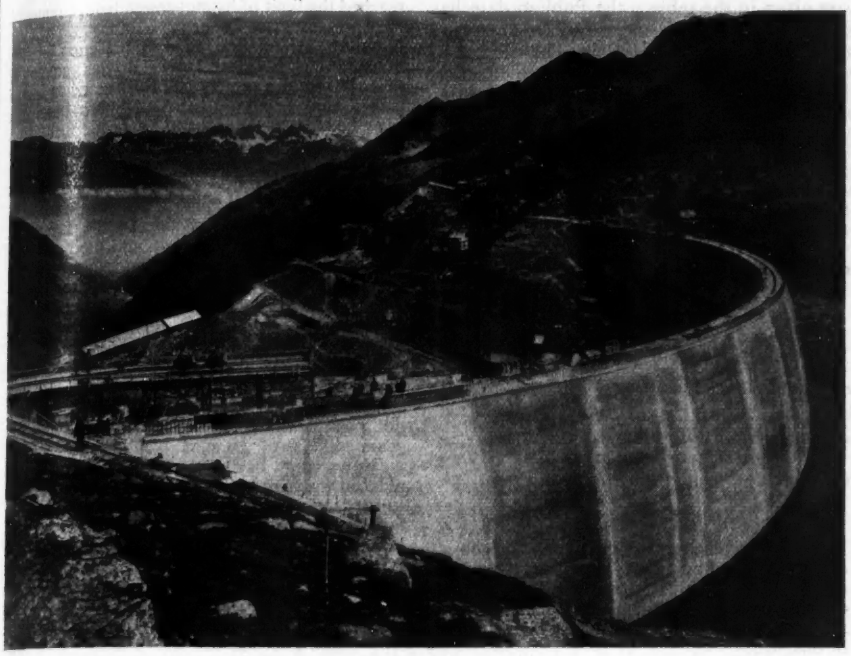


Fig. 42—Publino Dam

the Valtellina. The upper part of the Adda catchment lies to the west of the Montecatini's developments on the Adige, which have just been described (see Fig. 2 *ante*), and is one of the most favourable streams in Italy for hydro-electric exploitation. We have already mentioned some of the Edison Group's developments in this catchment, and the works of the Azienda Elettrica Municipale de Milano upstream of the Falck Company's area were described last week. The Falck Company has concentrated on the development of certain left bank tributaries of the Adda in two areas : the first on the Belviso torrent and the second utilising the Vanina and Armisa, and a short length of the Adda itself, all just downstream of the Belviso catchment. However, it has also built the Codera-Ratti project in this area, which has an installed capacity of 48MVA at the power station of Campo-Mezzola.

The complete scheme for the Belviso is typical of many developments in the upper reaches of Alpine rivers. The upper section of the scheme, the construction of which is still in its early stages, will consist of a seasonal reservoir at an elevation of 1430m, with a diversion tunnel just over 4km in length, with three side stream intakes, and a second tunnel diverting another stream to join the principal diversion at the surge chamber. Then penstocks will lead to the power station of Ganda, which will have an installed capacity of 50MW and will generate some 103 million kWh annually, with a head of nearly 550m. The seasonal reservoir will be an important one with a storage (50 million cubic metres), equivalent to an output of 110 million kWh, at the two power stations of the project ; it will be formed by an arch gravity dam, 135m in height.

The second stage of the project, which was completed in 1951, consists of a small arch dam on the Belviso forming a forebay at the site of the projected Ganda power station, at an elevation of 913m above sea level and with a capacity of 70,000 cubic metres. The diversion tunnel leads from this forebay to the surge chamber about 3km away. One side stream intake feeds additional water into the tunnel from a stream which passes it close to the surge chamber, and the flow from two further streams is led in by subsidiary tunnels totalling 4km in length. The penstock is a single steel pipeline, its diameter varying from 2m to 1·65m, with control gear consisting of two valves in series at its top end remotely controlled from the power station. It carries a maximum flow of 14·5 cumecs, is 924m in length, and with its various accessories weighs 1435 tonnes. It passes down the mountainside partly in open cut, partly in tunnel, and partly on a reinforced concrete structure, bridging the considerable irregularities of the natural slope.

The power station contains two horizontal 30MW turbo-alternator sets, each driven by two single-jet Pelton wheels. It is underground and provides another example of recent Italian practice in this respect ; it is shown in Figs. 38 and 40. The turbo-alternators operate at 428 r.p.m., generating at 10kV, 50 c/s, with a net head of 532m. The turbines are controlled by rotary valves. There is an auxiliary vertical Pelton wheel set of 625kW for the station auxiliaries, generating at 6·3kV, 50 c/s, at 1500 r.p.m.

There are two principal transformers, one of 60MVA and one of 30MVA, which are situated in a pit in the entrance portal of the power station, as may be seen from Fig. 38. They are wired so that power at voltages of 70, 130 or 220kV may be sent out from the various transmission lines connected to the switching station. The layout and plant is similar in general to the Montecatini's installations at Castelbello and Glorenza and, as at those stations, the transformer may be used to transfer power from, for instance, the 130kV to the 220kV lines when the power station itself is idle.

The estimated annual output from both stages of the Belviso scheme is 240 million kWh, but until seasonal storage is provided the output at Belviso power station alone will be about 106 million kWh.

The second series of developments mentioned earlier centred on the Vanina and Armisa torrents, follows along similar lines to the one already described, with seasonal storage at high levels and extensive diversion works, including catchwater aqueducts from subsidiary torrents. The developments here are more complicated, however, and there are five principal high-level reservoirs and five power stations ; the exploitation of the catchment has still to be completed by the construction of further catchwater aqueducts. There is also a run-of-river scheme of 10MW installed capacity and 44·5m head on the Adda itself.

Reservoir	Lago Venina	Publino	Scais
Useful storage capacity, cubic metres × 10^6	11·2	5	9
Top water level, metres above sea level	1,824	2,135	1,425
Height of dam, metres	61	40	60
Length of dam, metres	175	205 (on curve)	400
Volume of dam, cubic metres ...	95,000	36,000	200,000

An interesting variety of design is given

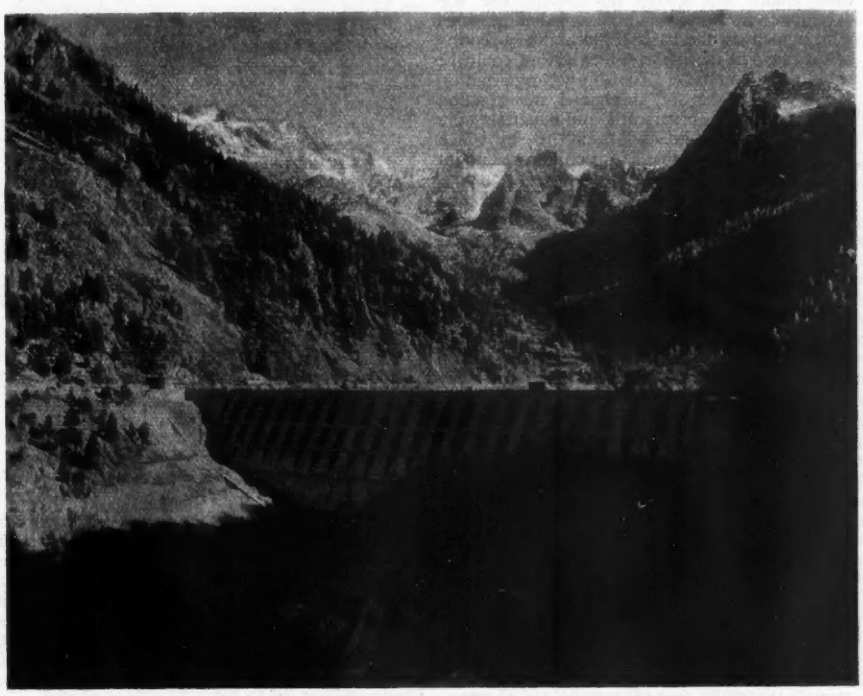


Fig. 43—Scais Dam

by the dams of the various reservoirs here. The largest reservoir, Lago Venina, is formed by the multiple arch dam shown in Fig. 41, which was built in the years 1923–26. The Publino reservoir (Fig. 42) is formed by an arch dam which was completed in 1951, whilst Scais reservoir (Fig. 43) is formed by a buttress dam built in 1936–39, which is of the same general design as the large dam of S. Giacomo, described last week. The principal data for these reservoirs are given in the table ; the Publino dam has a chord length of 173m, its radii of curvature varying from 91m to 109m. The other two seasonal reservoirs mentioned are smaller, each being of about 500,000 cubic metres capacity. The power stations have heads varying between about 800m and 250m, with installed capacities of 55, 10, 30, 10 and 2MW. Altogether, the hydro-electric power stations of the Falck Company generate about 700 million kWh annually.

(To be continued)

Soil Failures in a Railway Cutting

No. II—(*Concluded from page* 385, *March* 13*th*)

Two large slips recently occurred on the down side of the British Railways Western Region main line to the West of England. Both slips occurred where the line passes in cutting through the Reading Beds, where they are thinly overlain by pebble gravel. The somewhat unusual causes of the slips and the measures used to repair them are described here.

The Sonning Slip

As at Twyford, the first signs of trouble at Sonning were when the tracks began to move. The slewing effect was not so noticeable, however, but the track lifted at an alarming rate. The movement was confined to the down main line, the one nearest to the toe of the cutting. A crack developed three-quarters of the way up the bank and began to open rapidly.

The movement of the slip was recorded in terms of the amount that the track had to be lowered to keep it at its original level (Fig. 5).

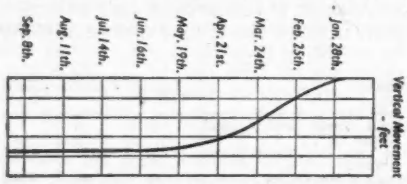


Fig. 5—Sonning Slip—Movement of Down Main Line

This was not regarded as a scientifically accurate measurement since it was the sum of a number of observations made by the ganger in charge of the lowering. The total of the observations was approximately correct as could be judged by the fact that the pipes of the cess drain were finally well above rail level. The slip developed very rapidly and the remedial measures were agreed on the basis of preliminary reports before the soil mechanics investigation could be regarded as complete. The slip was reported on January 21st, the soil mechanics investigation commenced on February 5th, and materials were unloaded on the site on March 3rd, by which time the down main line had been lowered about 13in.

The method employed in the soil mechanics investigation was the same as the one which had been successful at Twyford. A geological cross section was determined at the worst part of the slip. Hand borings were used for holes up to 21ft in depth and the two holes which needed to be 41ft and 32ft deep were put down with a mechanical boring rig.

The findings of this investigation are shown in Fig. 6, the positions of the boreholes being shown and also the shear strengths of the clay samples. About 32 per cent of the undisturbed samples were tested in a triaxial compression machine and the rest by the unconfined method.

The cutting was 54ft deep at this point and its slope 1 : 2. The horizontal strata were for practical purposes identical with those at Twyford except for variations in depths. The unusual feature was the presence of the curved sand layer. Considerable care was taken to verify this unusual configuration, three boreholes being put down within 11ft, and the investigation consequently took longer than had been anticipated. A slip had occurred some fifty years previously at this point of which there was no record. The remedial measures then taken consisted of removing a large quantity of clay to the depth shown in Fig. 6 and replacing it with ashes. The object of this work and the type of slip which it counteracted was regrettably not known. One thing was certain, however—that it was successful, since no movement had been noted until the beginning of this year.

The cutting runs across the natural land drainage towards the Thames. The gravel stratum was saturated with water which flowed down the cutting in large quantities. The water levels recorded in the boreholes after leaving them for forty-eight hours showed that a hydraulic gradient existed between the curved and the horizontal layers, thus indicating that there was an outlet for the water in the horizontal layers, possibly caused by the boreholes, and implied that the level observed in the horizontal sand layer was the maximum under existing conditions. The track drainage was in good order, a steady flow being maintained in the direction of Reading. The ballast was dry and very little water was found at the junction between the ballast and the formation.

Sonning cutting is an example of the use of vegetation to stabilise a clay bank and various trees up to 2ft in girth and 40ft high grow throughout the cutting. The slip having once started, however, it was felt that it was important to lessen the adverse effect of the wind forces on the slipping mass. The trees in the area were, therefore, cut down to a maximum of about 15ft, ensuring that they were not killed in the process. It was recognised that these trees performed a useful function in that their roots reinforced the cutting slope. Indeed, it was felt that the movement only reached its maximum rate when the tree roots had been broken, and that without this action the slip might have reached the limit of its movement before remedial measures could be applied.

As an explanation of the presence of the unusual curved sand layer, it was suggested that the stratum may have been the trace of the curved bank of an old river. A sharp bend in a river bed might cause sand to be deposited on its bank in this fashion. Indeed, the part of the sand layer exposed when the slip had developed fully displayed an appearance that corroborated this theory. Against this theory were two facts. First, the clay on either side of the layer had similar characteristics, which indicated that the clay was deposited on top of the horizontal sand lens and that the curved layer was a later phenomenon. And second, that the presence of the horizontal layer vertically beneath the curved one was hard to explain.

The position of the curved layer resembled markedly the possible position of a similar type of failure to that observed at Twyford. Was it not possible that the slip which occurred fifty years ago was of the same type ? The remedial measures could have been effective because they reduced the hydrostatic head by allowing ingress to the track drainage. This was hinted at by the fact that the maximum level of water in the sand lens was coincident with the level of the centre cess drain. The slip having once occurred, and a drainage channel opened, the water passing through the slip plain could have carried sand with it which was deposited to form the stratum. The arguments against this theory were that the sand appeared to be a natural deposit, and it also resembled closely the sand of the horizontal layer, implying that the sand was deposited by water moving upwards through the slip plane—a very unlikely supposition.

The cause of the slip itself was not difficult to explain ; the low strength of the sand under hydrostatic head gave a factor of safety of unity on a slip circle with its centre as shown in Fig. 6. The slip was assumed to be circular from ground level on the bank to a point vertically beneath the centre of the slip circle. As Fig. 6, shows this assumption was a close approximation.

The forces acting on the mass enclosed by the radii of this circle were :

(1) The out-of-balance moment of the mass.

(2) The active resistance of the ballast (this value was taken since the ballast was likely to be disturbed during the course of day-to-day maintenance).

(3) The passive resistance of the clay between the sand layer and the ballast.

(4) The resistance of the sand layer due to its shear strength.

These were the forces that applied at the time of the first slipping. It was not until the subgrade was disturbed by the slip that its strength was sufficiently reduced to carry the slip circle through it. At a later stage the slip undoubtedly changed its character as was shown by the change in the movement of the down road. The path of the slip circle through the subgrade is shown

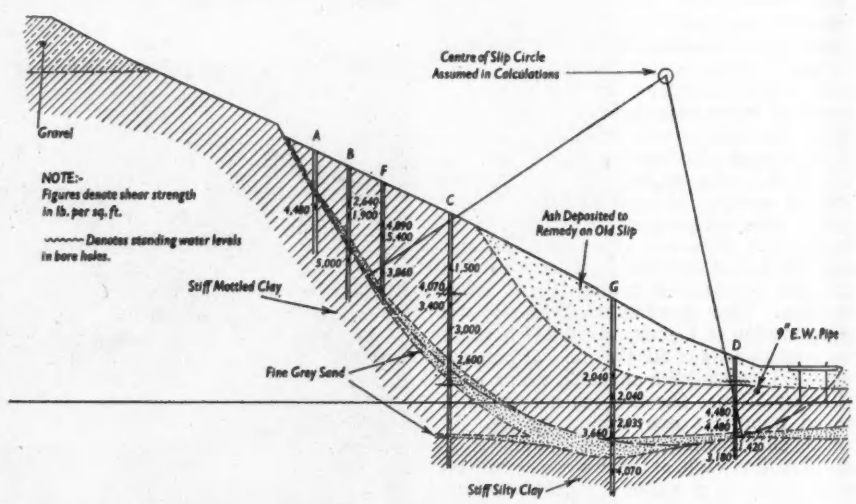


Fig. 6—Cross-Section Through Worst Part of Slip in Sonning Cutting

by a dotted line in our illustration (Fig. 6).

All these forces could be considered in terms of their moment about the centre of the slip circle, and they were all calculated for a strip a foot wide. The out-of-balance moment M_B calculated using unit weight of clay as 136 lb per cubic foot, was evaluated at 4,973,000 lb-ft. The passive resistance of the clay subgrade, calculated as demonstrated for Twyford, from the formulæ

$$P_{E1}=\frac{H}{2}\left\{\gamma H\tan^2\left(45+\frac{\phi}{2}\right)+4c\tan\left(45+\frac{\phi}{2}\right)\right\}.$$

$$P_{E2}=W_B h_B H.$$

P_{E1} acting at 53ft from the slip circle centre was found to be 50,450 lb, and P_{E2} acting at 52ft from the slip circle centre, 2880 lb. The stabilising moment of the passive earth pressure :

$$M_P=2{,}820{,}000 \text{ lb-ft.}$$

As was found in the calculations for the Twyford slip, the active earth pressure was negligible. To give a factor of safety of unity the moment of the shear strength of the sand layer about the slip circle centre equalled M_S :

$$M_S=M_B-M_P.$$

$$M_S=2{,}153{,}000 \text{ lb-ft}$$

The length of the sand layer was 76ft and its radius 57·4ft. Thus, the average shear strength at unit safety factor was 494 lb per square foot.

The satisfactory determination of the shear strength of the curved layer was very difficult, but it was assumed that at some stage it reached this value and failure resulted. It was also assumed that this value could fall to 350 lb per square foot ; the force to be provided by the remedial works was then 5 tons per foot run at the sand level.

Remedial Measures

In repairing both these slips the same principle was applied. The works at Sonning, which were much greater in extent and cost, are therefore described first. The cause of the slip was known exactly and, paradoxically, this meant that the ways of dealing with it were numerous. The method adopted consisted of fixing the slipping mass to the solid stratum beneath it by the construction of seven buttresses or keys

The buttresses were constructed by digging holes 12ft by 7ft in plan, in the pattern shown in Fig. 7, to allow easy working without the fear of weakening the cutting too much. They were carried through the sand layer and into the silty clay stratum, as shown. This work was carried out while the slip was in progress and heavy timbering was used—a necessary precaution as was shown by the considerable movement that took place. Compressed air clay spades and light cranes were used, and the work progressed without difficulty until the sand layer was reached and pumping had to be started. At this stage, trouble was caused when the pumps, carrying a quantity of sand away with the water, caused large holes to be formed in the sand layer around the excavation. The timbering was carried successfully through into the silty clay layer, however, and the flow of sand largely cut off ; the holes were filled in when the stone backfill was placed. The stone backfill was layed in a matrix of 1 : 12 concrete except in the first two holes to be completed. No concrete was used in these two, and a 12in earthenware pipe was placed vertically in the middle of each of them, and used as a sump from which the general water level could be kept to a minimum, thereby increasing the strength of the sand layer ; 1½in gas pipes were also placed so that grouting of the stone could be carried out at a later date.

It will be seen from Fig. 7 that successive 12ft by 7ft holes were constructed, one behind the other, to form the buttresses, the maximum and minimum depths of excavation being 39ft and 21ft. After the first of them had been constructed, a noticeable decrease in movement of the track was apparent. However, the cutting slope began to belly out, as is illustrated by a comparison of the cross sections in Fig. 6 and Fig. 7, taken on February 12 and June 26, 1952, respectively. For the second series of 12ft by 7ft holes, the timbering on the high side of the first series had been left in place. When the timbering was again exposed by the excavation, it was found that it had moved from a vertical position to such an extent that over a length of 26ft it was 2ft 10in out of true. These developments, which were welcomed in view of the minimising of the threat to the running lines, illustrated that a secondary slip was occurring above the level of the tracks, as anticipated by the calculations, which showed that the most likely type of failure to which the buttresses would be subjected was in overturning.

To transfer the thrust from the slipping mass on to the buttresses, counterforts 7ft deep are to be constructed running up the bank, which will also function as drains. The water which collects in the gravel stratum will be tapped by shallow drains connected to the counterforts. It is intended in this way to prevent surface water running into the exposed top of the sand layer, which, in addition, will be covered with clay and

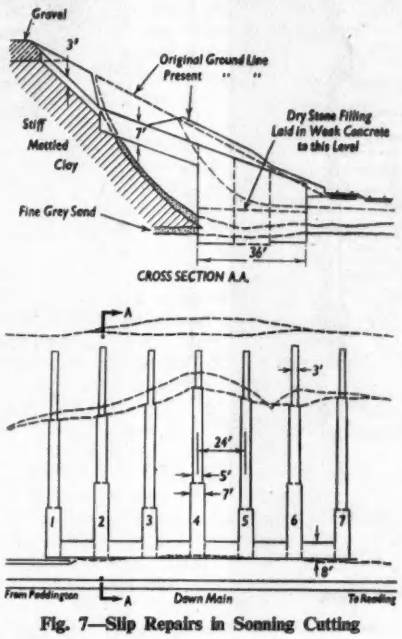


Fig. 7—Slip Repairs in Sonning Cutting

punned down. The track drainage will be reinstated where the old earthenware pipes have been broken by the slip, and the water collected at the level of the top of the grouted part of the buttresses and then run into the centre cess drain at about 6ft 6in below rail level. The new slope will be compounded, 1 : 3 over the slipping area and 1 : 1½ over the unaffected part, which reduces the out-of-balance force by 23 per cent.

In calculating the factor of safety of the buttresses, an out-of-balance moment of 3,819,000 lb-ft was to be counterbalanced by the strength of the sand layer (350 lb per square foot), equal to 1,500,000 lb-ft. The passive earth pressure was assumed to act in reducing the out-of-balance moment between the counterforts only. The pressure on the front of the buttresses was used in considering their stability.

Thus the stabilising moment of passive earth pressure $=\frac{(24-7)}{24}\times 2{,}820{,}000=2{,}000{,}000$ lb-ft, so that the unbalanced moment to be withstood by the buttresses equalled 319,000 lb-ft.

The criterion for deciding the safety factor was the overturning of the concreted portion of the buttress. The forces acting are shown in Fig. 8. The calculation was carried out for the smaller of the two types of buttress 24ft by 7ft in plan. The whole unbalanced moment was assumed to act through the counterforts, and resolved into the force F_H and a force F_V, which, acting through the centre of the slip circle, had no moment. F_H acted at a perpendicular distance of 51ft from the centre of the slip circle.

$$F_H=\frac{319{,}000}{51\times 2240}\times 24=67 \text{ tons.}$$

Resolving F_H with F_V and assuming the angle of shearing resistance of the drystone to be 60 deg., then

$$F_V=F_H\tan\left(\frac{2}{3}\times 60 \text{ deg.}\right)=56 \text{ tons.}$$

W_1, the weight of the drystone = 119 tons.
W_2, weight of concreted part of buttress = 105 tons.
U, hydrostatic upthrust on buttress = 47 tons.

P_{E1} and P_{E2}. The presence of the sand layer was ignored in calculating these values, and they were found in the same way as before.

$P_{E1}=1890$ lb $=0{\cdot}84$ tons
$P_{E2}=244{,}300$ lb $=105$ tons

Using these forces and the dimensions shown in Fig. 8, it was possible to take moments about the toe or heel of the buttress, the reaction on the base found, and hence the greatest stress on the base evaluated at 1·4 tons per square foot. The ultimate bearing stress determined by experiment was 3·5 tons per square foot. Thus the factor of safety for the smaller type of buttress equalled 2·5, and for the larger type of buttress, calculated in the same way, equalled 3·1.

When remedial measures were first called for the overriding factor to be considered was which method would have the quickest effect in arresting the movement of the main line. The easiest emergency measure to apply was the construction of buttresses. The job could be started without plant ; timber and hand tools were readily available and so was labour skilled in this type of work. In the first instance the construction of buttresses was the obvious course, and two holes were started on March 10th. At the same time calculations of efficacy in terms of safety factor for assumed conditions and estimates of cost were made. An alternative scheme involved the construction of a reinforced concrete retaining wall founded in the stable stratum below the sand layer and extending the length of the slipping area. The thrust was transferred from the clay mass to the wall and thence to the stable stratum. The cost for a similar factor of safety was about the same ; this solution was not used because the skilled labour required for reinforced concrete construction was not readily available. With a third alternative a satisfactory factor of safety could have been obtained by compounding the existing slope of 1 : 2 to be 1 : 4 over the slip and 1 : 1½ above it. This would have had the effect of moving the edge of the slope back a maximum of 8ft, which would still not have involved any movement of the boundary fence. This scheme envisaged the use of a mechanical excavator operating from the stable portion above the slope, and the idea was regretfully

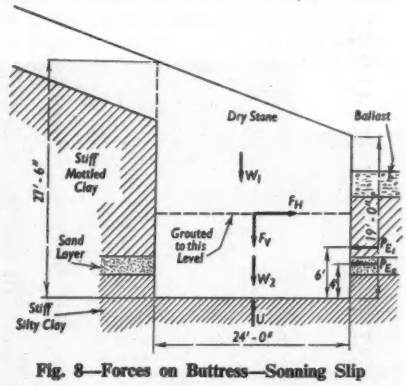


Fig. 8—Forces on Buttress—Sonning Slip

abandoned (it gave a 50 per cent cost saving), as the safety of traffic might have been endangered.

The prime cause of the failure at Twyford was the hydrostatic head which had collected in the sand lens. This was reduced to an economic minimum by the use of 6in diameter cast iron pipes, with perforated ends, which were built into the buttresses, the perforations being at the level of the sand lens. The pipes terminated slightly above the level of the drain in the centre cess, i.e. 12ft above the sand lens. The buttresses were then to be connected by earthenware pipes to the centre cess drain. The hydrostatic head was thus limited to 12ft. A slip plane having formed and the effective strength of the clay being very greatly reduced, it was necessary also to provide another stabilising factor, which, as stated above, also took the form of buttresses and counterforts. The original slope was not as great as at Sonning and consequently the remedial measures were not so extensive. The buttresses measured 24ft by 7ft and were spaced at 21ft centres, and the counterforts are to be made to drain the gravel layer directly. The buttresses were constructed in dry stone.

The investigations described above were carried out on the Western Region of British Railways by Mr. J. P. Slee under the direction of Mr. M. G. R. Smith, the civil engineer of the Western Region.

Fig. 9—Floating-in 250ft Truss Span

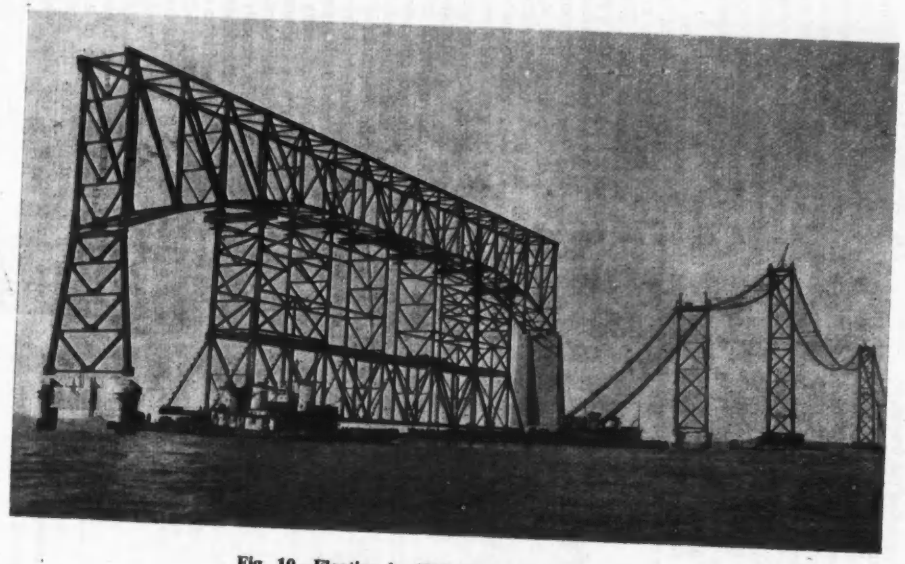


Fig. 10—Floating-in 480ft Deck Cantilever Truss

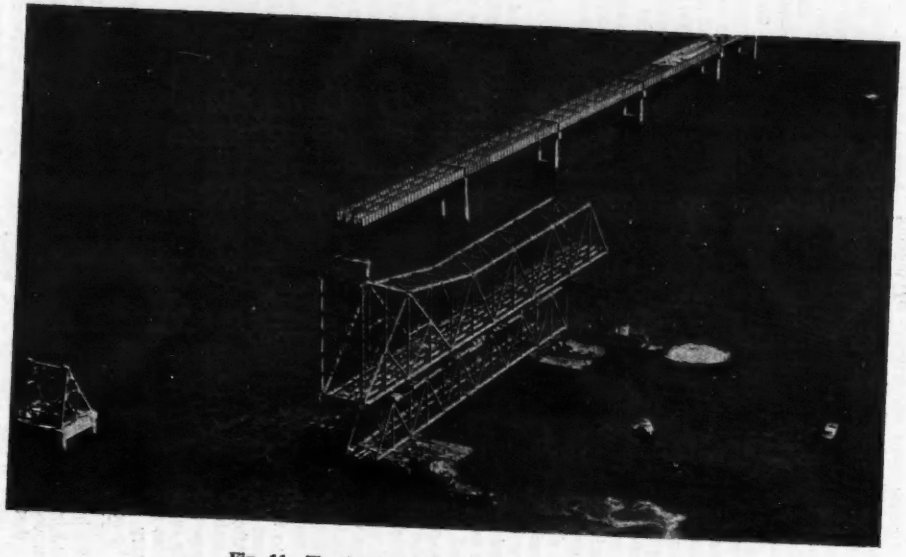


Fig. 11—Floating-in 470ft Through-Cantilever Truss

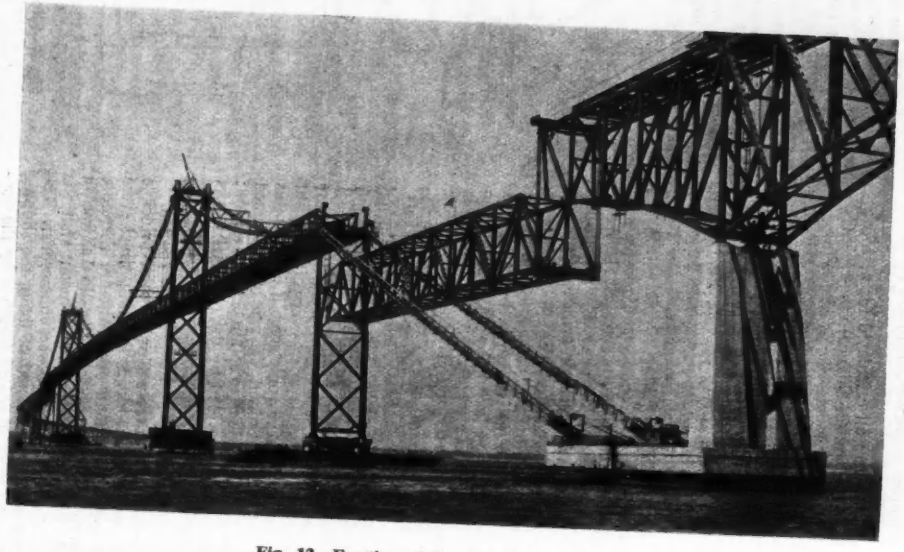


Fig. 12—Erection of Final 360ft Truss Span

The Chesapeake Bay Bridge

(By our American Correspondent)

No. II—*(Concluded from page 381, March 13th)*

The Chesapeake Bay Bridge, one of the largest recent American bridge schemes, was opened to traffic on July 30, 1952. It forms an important link in the system of highways along the East Coast of the United States. The project extends over a considerable length, the shore-to-shore distance being 22,990ft, of which 21,286ft are covered by bridge structures, the suspension bridge over the main ship channel having a central span of 1600ft.

A CONTRACT for the entire superstructure of the Chesapeake Bay Bridge, involving 27,000 tons of structural steelwork and worth 16,000,000 dollars, was awarded to the Bethlehem Steel Company, of Bethlehem, Pennsylvania. Probably the most interesting aspect of the superstructure work is the fact that site erection took place almost without conventional falsework. The rather deep water at the bridge site would have made the use of such falsework both costly and difficult. The many truss spans and some girder spans were, therefore, assembled at a temporary erection dock and floated into their respective positions along the bridge structure on barges. Various stages of this procedure are indicated in the illustrations on the opposite page.

The steelwork for some of the inshore 60ft beam spans was placed by a mobile crane working on land, while the remainder of the beam spans and all the 100ft girder spans were placed from a floating derrick which is illustrated in Fig. 13. It consists of a steel hull 128ft long by 64ft wide, supporting a triangular-shaped steel tower, whose sides measure 33ft. Mounted on the tower is a derrick with its base 118ft above the water. It has a lifting capacity of from 7 to 33 tons, depending on the working radius.

Two of the 100ft girder spans at each end of the bridge were left open, to facilitate the erection of the 200ft girder spans on top of the adjoining spans. On completion of erection these long spans were then floated off and positioned over their respective piers.

Additional steelwork was bolted to two of the 200ft girder-span sections to form four 250ft members for supporting the falsework on which the truss spans were later assembled. While the beam and girder spans mentioned above were being placed, four bents for a temporary " erection dock " were constructed approximately 70ft north of the bridge alignment for the 300ft deck truss span between piers 20 and 21. This is the last of the ten deck trusses on the west side and is over a mile out from the shore (a complete list of the various spans was given in Part I). The bents consisted of " H "-piles, driven deep into the sandy bottom, spaced 90ft, 60ft and 90ft apart. Upon completion of the superstructure erection, divers burned these piles off close to the bottom of the bay. The bents supported the four 250ft girder assemblies, which were laid like stringers lengthwise to form a dock. Supported on the heavy grillage of these girders were two steel falsework towers across which the various truss spans were assembled and tied together (Fig. 14). These rectangular towers measured 59ft 5½in along the erection dock by 28ft across. Their height was altered to conform with the levels at the ends of each truss according to the bridge gradients of the particular span. As may be noticed at the right-hand side of Fig. 14, assembly proceeded at the erection dock with the aid of derrick cranes, mounted on the truss span between piers 20 and 21, hoisting steelwork members from the supply barges to the particular truss span being assembled on the 250ft girders of the erection dock. Altogether, these cranes were used to assemble a total of twenty truss and cantilever spans over the adjoining temporary erection dock. One by one, as the trusses were completed, barges were floated in under the four 250ft girders, the whole assembly was floated off and the completed truss placed in its permanent position on the respective supporting pier (Fig. 9). The nine trusses on the western side of the bridge, from pier 11 to pier 20, were erected first, from the inshore span outward. Later another falsework bent was driven at the erection dock to accommodate the longer 480ft cantilever trusses for erection in the same manner. However, the 250ft girders that served as the lower falsework for the spans up to 300ft, were replaced by one of the trusses, which, in turn, supported the truss being erected (Figs. 10 and 11). The cantilever truss spans were brought in from either side of the bridge, depending on the movement of the tides. Thus, spans between piers 11 and 19 and between 20 and 21 were all floated in from the north. However, the span between piers 19 and 20 was floated in from the south because it was a closing truss and the curve of the bridge prevented it being floated in from the north as there was not sufficient clearance. The following description is representative of the procedure employed for the truss spans.

Water was pumped from the holds of the

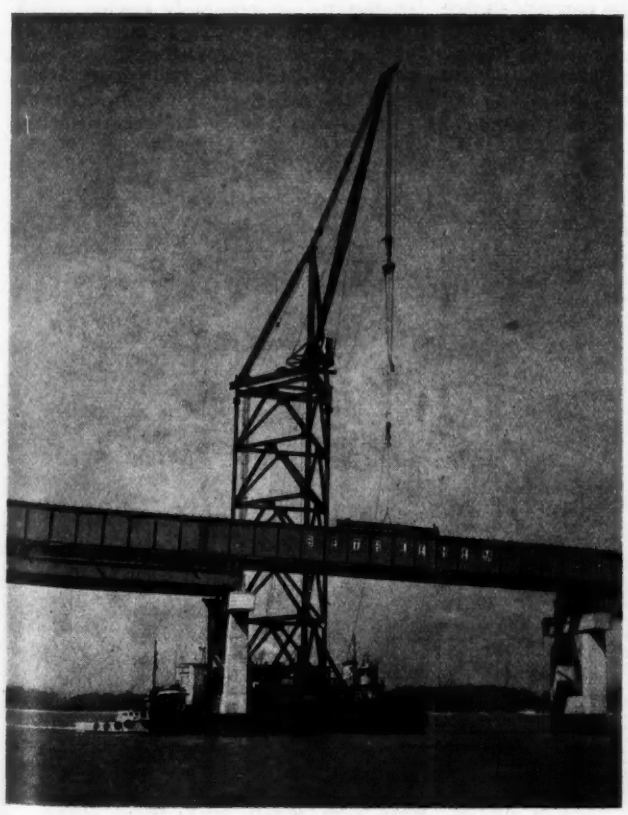


Fig. 13—Floating Derrick Crane

Fig. 14—Assembly of Truss Span at Temporary Erection Dock

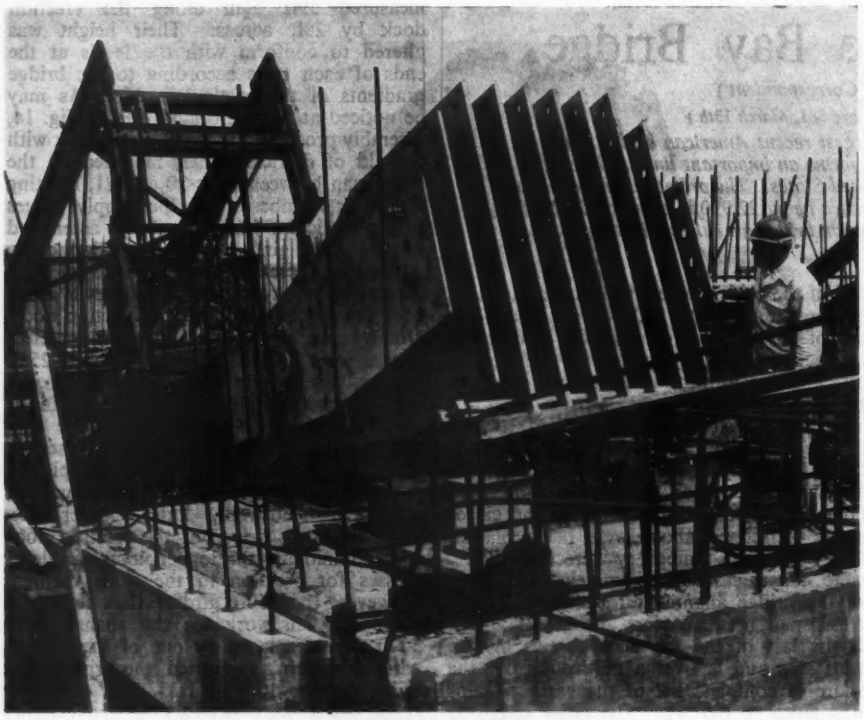


Fig. 15—Anchorage Plates

twin pairs of barges moored between the bents at the ends of the erection dock, thus lifting the weight of the girders, the falsework towers and the truss off the bents, making the entire structure waterborne. Two powerful tugs manœuvred the float to bring it into the gap between its respective piers. For one particular truss the falsework towers were about 61ft and 70ft high at the west and east ends, respectively, and the truss was about a foot higher on the float than its final level on the bridge. When the tugs pushed the float nearly up to the piers, lines were made fast to anchors embedded in the bottom of the bay north of the bridge. Floating buoys marked the position of the anchors, enabling them to be easily picked up and moved. Once the barges were secured to the anchors the tugs backed off and the winches on the barges pulled the float the rest of the way into the piers. Certain small, final, adjustments were made with chain hoists. Once the horizontal alignment was satisfactory, the holds of the barges were slowly filled with water, thus lowering the truss down to its seat on the piers, where it was secured in place. Finally, the float with the girders and falsework towers was towed back to the erection dock to enable another truss to be assembled.

Fig. 12 shows the final 360ft truss span section being hoisted into position to complete the erection of the superstructure. This truss had previously been used as falsework in the floating of earlier spans and was finally itself floated into position on barges. It was then hoisted to bridge level by wire rope tackle suspended from the adjoining structure.

The Suspension Bridge

The suspension bridge has a centre span of 1600ft and two side spans of 661ft 3in. The two main bridge towers have a height of 344ft above mean low water, and the tower legs are cross shaped in plan, with a fixed transverse width of 6ft 6½in and a width parallel to the bridge centre line varying from 9ft 11in at the tower base to 6ft 6½in at the top. Sections of the tower legs weighing about 25 tons each and varying in length from 20ft to 30ft and completely fabricated were transported to the bridge site by barges. The lower six sections of each leg were erected with a floating derrick crane ; all subsequent sections were erected by two "Chicago boom" jib cranes mounted on the two tower legs and "jumped" from one level to the next. No steel shims were used to obtain correct bearing of the steel tower structures on the piers ; instead, the concrete surface of the piers was finished to the exact level, making use of portable grinders to remove any high spots, and the anchor bolts were set precisely in the concrete before lowering the bottom tower sections into place.

An unusual aspect of the erection procedure (erection is shown in progress in Figs. 15 and 16) was the use of shop-fabricated prestressed, twisted bridge strands instead of the site spinning of individual, parallel wires. The main advantage claimed for this method is that it allows a considerable part of the cable fabrication to be performed in the shop and thus reduces the erection time required at the bridge site. Each of the two cables comprises sixty-one twisted strands almost 4000ft long—fifty-five large ones and six small ones. The strands were shop fabricated at Trenton, New Jersey, and were prestressed, measured, marked for saddle positions and provided with special anchorage sockets. The saddle positions were marked so as to give each strand its correct sag for its designed final position in the cable. Each strand was delivered on a reel and then pulled off and into place in the bridge cable by a conventional cable-spinning tramway. However, the cable-spinning tramway was equipped with a "strand carrier" in place of the usual spinning wheel. This strand carrier pulled one strand, consisting of sixty-nine wires, during each trip lasting about twenty-five minutes. The erection contractor estimated that parallel wire spinning would have taken three times as long with the same amount of equipment ; the time saving was not greater because there was a limit to the number of strands that could be placed daily. A day's work included the temporary emplacement of one horizontal layer of strands, comprising five to nine strands. This step involved the approximate positioning of the layer in the final cable location. Then, at night, when temperature variations were less severe than in the day time, a second gang moved on to the towers and catwalks and, with the aid of chain hoists at the saddles, carefully adjusted the position of each strand. The objective was to set each strand to the correct sag relative to the previously erected strands. The first strand erected in each cable was used as a guide, and set with its saddle marks precisely in line with the apexes of the saddles.

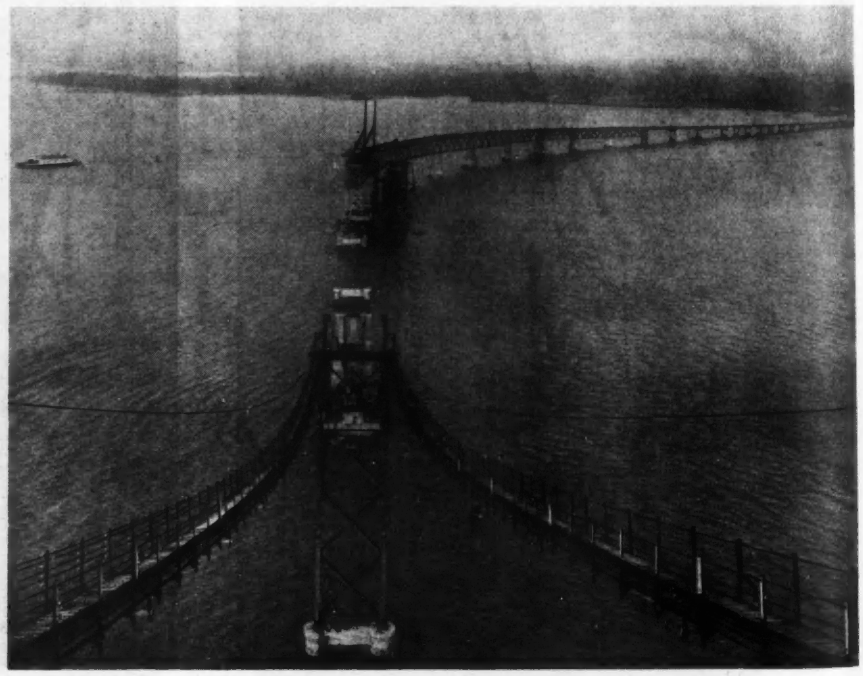


Fig. 16—Emplacement of Initial Cable Strands

Adjustment took place first at the main tower saddles and then at the side pier saddles. At the anchorages, jacks pulling on the sockets made the final adjustment for correct length; proper shims were then placed, and the load was transferred through bearing rods to the anchorage plates.

The two strand sizes employed were $1\frac{11}{16}$in in diameter (sixty-nine wires) and $^{29}/_{32}$in in diameter (twenty-nine wires). The strands in successive layers were of opposite lay, to facilitate the nesting of the individual wire and to prevent any inter-strand slipping. Altogether, sixty-one strands made up a bridge cable having an overall diameter of $13\frac{29}{32}$in. This dimension includes aluminium fillers placed to fit the corrugations between the outside strands and a final layer of 9 B.W.G. wrapping wire.

The suspender ropes hanging from the main bridge cables are spaced approximately 40ft apart, a distance equivalent to the length of two panels of the suspended bridge structure. It was therefore decided to pre-assemble four-panel sections of the suspended steelwork at the fabricator's shops in Baltimore and to float them on barges down the Chesapeake Bay to the bridge site. Here they were hoisted into position by eight-part wire rope falls hanging from special clamps on the bridge cables and were subsequently pinned to their adjacent sections. The suspended structure sections were joined initially only at their top chords, the lower connections being left unpinned until all sections were in place. In this way the sections were free to adjust themselves to cable rise and fall as load conditions varied during the progress of erection. According to the erection contractor, the vertical position of the cables at midspan varied by as much as 32ft during erection.

Deck Paving

The deck paving of the bridge consists of a reinforced concrete slab topped by a 2in wearing course of asphalt. Over the beam spans at the ends of the bridge the slab is of normal concrete $6\frac{1}{2}$in thick, but for the remaining $3\frac{1}{2}$ miles of deck, lightweight concrete was used in the base course slab. The slab thickness of this lightweight concrete varies somewhat along the span. Over the truss spans the slab is $5\frac{1}{2}$in thick; over the 100ft girder spans it is $5\frac{3}{4}$in thick, and over the 200ft girder spans it is $6\frac{1}{2}$in thick. Paving commenced on April 18, 1951, on the west side of the bridge, where the steel erection had made the most progress. Later in the year, when the steelwork erection had advanced on the east side of the bridge, paving also commenced at that end. Paving was done over the full 28ft deck width, one span at a time, from the high or outer end working back toward the shore. Altogether, 2440 cubic yards of normal concrete and 8720 cubic yards of lightweight concrete were placed in the bridge deck. The construction of the deck was sub-contracted to the Kaufman Construction Company of Philadelphia.

The J. E. Greiner Company, of Baltimore, were responsible as consulting engineers for the design and the supervision of construction of the entire bridge scheme.

Steels for Steam Power Plant

THE INSTITUTION OF MECHANICAL ENGINEERS

At a general meeting of the Institution of Mechanical Engineers, held on Friday last, March 13th, a paper on "Steels for Steam Power Plant." by Mr. A. M. Sage, B.Sc., was presented and discussed.

The paper gave a review of the work carried out for the Steels for High Temperature Committee of the British Electrical and Allied Industries Research Association between 1930 and 1952.

Discussion

Dr. R. W. Bailey, who opened the discussion, said that the paper was unusual in two respects, namely, that the subject matter related to work carried on under a committee over a considerable period, and that the author had had the difficult task of looking at the reports of the work of others and preparing a summary without the advantage of having had an intimate association with much of the work at the time of its execution.

Having regard to the duration of the committee's activities and the considerable resources which had been available to the committee, namely, mechanical testing and metallurgical facilities of the National Physical Laboratory, and the collaboration and assistance of industry, both of power plant manufacturers and of steel makers closely engaged in the supply of material and parts for power plant, his personal view, long held, was that the significance and practical value of the work had not been adequately and more widely known to engineers and, in consequence, more fully used. For example, cases within his own knowledge could be cited where an alloy steel had been used, although carbon steel would have been equally satisfactory and also substantially more economical. In one case, his opinion had been sought where repeated failures of austenitic steel superheater tubes at flash butt welds with carbon steel tubes had taken place, and the remedy had been to replace with carbon steel tubes. A better knowledge of what carbon steel could undertake at high temperatures, as offered by the work of the J/E Committee, as well as confidence in its use, would have justified the use of carbon steel in the first place, and would have avoided costly outages of expensive plant. In his opinion, carbon steel was better than was often thought, and alloy steel frequently was not quite as good as might be imagined. The carbon steel, however, must possess good high-temperature properties, and these could and should be assured.

A statement made early in the paper might convey a wrong impression as to the temperature limitations of carbon steel, although later in the paper the position was put more satisfactorily. The statement was made on page 4 that "The creep tests to determine design data showed that at temperatures in excess of 842 deg. Fah. (450 deg. Cent.) the stress-carrying capacity of carbon steels fell to values which tended to make their use uneconomic on account of the heavy sections required, for example, in superheaters." This statement was indefinite as to temperature for the example chosen because, of course, the metal temperature of a superheater tube, especially at its outside, was higher than the steam temperature within the tube. Except for this particular element, the metal temperatures of other parts, superheater steam drum, steam piping, valves and turbine parts, were at steam temperature. In the case of steam piping, he had shown in his paper "Steam Piping for High Pressure and High Temperatures" that using the stress values produced over ten years ago by the J/E Committee researches, and by making a rational approach to the design problem, 900 lb per square inch pressure at 900 deg. Fah. was within the capacity of the carbon steel steam pipe material tested, without excessive pipe-wall thickness.

On page 4 of the paper, there was reference to the work of Prömper and Pohl in Germany; what they had done was to make tests of two steels, one with molybdenum added and the other with vanadium added, so that what was said in the paper should read not "molybdenum and vanadium," but "molybdenum or vanadium." The molybdenum-vanadium steel had been invented in this country, and it had not only been brought out, but tested and put into service in this country, in about 1938.

He did not think that molybdenum-vanadium steel had been used for many turbines; although it had been introduced as far back as about 1934, it had been done on laboratory furnaces; and as soon as it had been proved to be a promising material, the first commercial casting of that steel had been made by Colville's and had applied to actual scantlings for turbines, for the diaphragm, steam piping, and so on. The result had been so satisfactory that it had gone into service and the latest information he had was that the particular machine had done 60,000 hours, and it was hoped to get one of the steam pipes back so that it could be looked at after 60,000 hours' service. It had had to stand up to a pressure of up to 1350 lb per square inch and 965 deg. Fah.

As was pointed out by the author, relaxation tests came in significantly in the case of bolted joints. If there was one thing an engineer was concerned with in joints, it was that they should not leak. Therefore, the choice of a material and the knowledge of its properties for bolted joints was an important matter and needed to be fully understood. One of the questions which, he imagined, came to the minds of most engineers was this: all these creep tests that were made in creep relaxation were done by heating up the material to working temperature, putting on a certain strain and then, under the creep going on, the creep strain exchanged with elastic strain and so the load went down. But no joint was bolted up that way. A joint was bolted up cold; in other words, the whole of the straining action put on the joint was applied when the joint was cold, and the joint itself had to go through the process of heating up. It did not get to its working temperature in a flash; it had to go on heating up, so that the material was going through a whole variation of temperature in which all the stress-strain diagrams that the material had at different temperatures were being passed through in the process of heating up. In such a case there would be plastic strain taking place and the question was this: did the creep relaxation test which had been carried out give the same answer as would be obtained if the material were loaded as a bolted joint was loaded? He had made a few tests to establish the situation and very fortunately it had happened that the two did eventually give about the same performance, so that any engineers who might have felt uneasy about the difference between the testing and actual conditions might have had their doubts removed by what he had said.

In dealing with the relaxation tests he wanted to draw attention to the tests and

the work referred to on page 8 of the paper, where it was stated : "This work has also enabled a mathematical relation between relaxation time and stress to be derived." It was necessary to understand this quite definitely to refer to the tests on the carbon steels. When dealing with alloy steels (which, of course, all these bolts were), one had to deal with them in such a way as to find out what they did, because they were not quite so simple in their behaviour as the carbon steels. He had found that it was extremely difficult indeed to make a prediction of what the tail end of the curve was going to be for an alloy steel bolt. As he had mentioned earlier, engineers were always anxious to get an answer quickly if they could, and short-time creep tests had been devised by various people to do that. It had often been suggested that if one could use creep relaxation tests instead of the ordinary creep tests, one could shorten the time of testing. It was his own firm opinion that one could not do so.

It was mentioned in the paper, in connection with creep relaxation, that other work was being done to meet the higher temperatures that had to be dealt with. He wished to point out a fact which had been made prominent by this movement to very high temperatures. It was not possible to put on a bolt any more than the elastic strain it could carry. The amount of creep that one took up in a bolt must be less than the elastic strain that one put on. The question was what elastic strain could be put on a bolt. One was limited by the elastic limit of the material even at atmospheric temperature, and when one had done that one found that probably it was not possible to get more than 0·0015in taken up as creep. If a bolt joint was to be obtained which would last for the life of the plant (which was what was aimed at in some cases), it was necessary to have enough elastic strain in the bolt to look after the creep that would take place, which meant cutting down the creep to a small amount—which would mean a large bolt. Therefore, the difficulty, which only became an important and serious matter at very high temperatures, was that one just could not, without getting an excessively large joint, get the kind of life that was expected from the plant. Retightening was therefore absolutely necessary in those cases. With a welding there was a better position, since there was no dependance on the strain of the bolt ; but anyone who had made an attempt to design a joint to withstand these highest temperatures—say, 1050 deg. Fah.—when thinking of 100,000 hours (and some people said that they wanted it for 200,000 hours), knew that it did present a problem ; and this would be one of the problems that the J/E Committee would need to give attention to when it considered the results it would get from the creep relaxation tests being carried on.

Towards the end of the paper the influence of various elements was summarised, and one could agree with the general statements that were made about those elements ; but there was a factor which had been overlooked so far which was important, namely, that when one put an element into a steel it generally had two effects ; one was that it would alter the properties of that material at the lower temperatures ; and secondly, it would most probably (in fact, he could think of only one material where it did not seem to work) weaken the material in the course of a long time at high temperature, as, for instance, happened with heat-treatment. In all the cases where they had compared the creep resistance of a quenched and tempered alloy steel with the properties of the steel in a normalised condition it had been found that the normalised material had the greater staying power when it came to the long time and the high temperature. Tests had shown that if one judged a steel on its initial behaviour on a short time, one might be completely misled because of the fact that an element put into the steel would generally stiffen up the steel and give a false idea of what it could do. He had found this in some tests in which a chromium-molybdenum steel had been compared with a chromium-molybdenum-silicon steel.

This was an aspect of the alloy steels which he felt that the J/E Committee would need to give attention to now that these high temperatures were being reached, because there was the difficulty of getting any steel to stand up to its loading at very high temperatures.

Mr. W. E. Bardgett said that in the section dealing with " Creep and Design Data " it was stated : " A study of the behaviour of rolled bars and plates in forty-seven steels, stressed at 4 tons per square inch and a temperature of 842 deg. Fah. (450 deg. Cent.), showed that good creep properties were more consistently obtained with acid open-hearth steels than with basic open-hearth steels." This was quite correct on the basis of the examinations made, but it was possible to get very high creep properties from open-hearth steels made in a certain way, similar to the acid open-hearth.

At the top of Table I there were the words " Normal " and " Abnormal." Dr. Bailey had referred to " Abnormal " ; this had cropped up in the early days, when steels of low creep resistance had been encountered. The N.P.L. had examined first a number of superheater tube steels and then had turned to some of the other steels and presumably had remarked, " Ah, abnormally high." The " abnormal " ones were " abnormal " because they had been largely encountered after some of the other steels of higher creep resistance had been tested ; they were not really abnormal, but were quite normal for the type of production and purpose. There were thousands and thousands of tons of these steels being used and they were serving quite well. He therefore drew attention to the fact that the word " abnormal " should not be interpreted too literally.

In the section " Abnormal Steels and the Effect of Minor Elements " there was the term " anomalous results." He thought it was time to forget about the terms " normal " and " anomalous " ; they could be controlled, and particular properties were characteristic of particular steels.

Under the paragraph relating to manganese it was stated : " The presence of not less than 0·6 per cent manganese seems desirable in all carbon steels, as it appears to have a strengthening effect on the ferrite and, in addition, increases resistance to spheroidisation." No doubt that was correct on the basis of the steels examined, but he thought it was quite an unnecessary restriction. One could get absolutely first-class creep properties from a steel with 0·35 manganese, and in fact some of the steels in Table I did have slightly less than 0·6 per cent. There was no question that manganese was a factor in creep resistance and that creep strength was usually raised with increased manganese content, but he thought the limitation of 0·6 per cent was unnecessarily restrictive.

In the paragraph dealing with silicon it was stated : " . . . . and more than 0·2 per cent appears desirable to ensure that a steel shall not have poor creep properties." That, again, was an unnecessary restriction in the light of experience. One could quite readily go down to 0·1 per cent and, he believed, a little less ; but one had to watch the method of deoxidation of aluminium, aluminium being a major factor.

In the paragraph on aluminium and oxygen there was again the statement that it had been found desirable that the contents of silicon and manganese should not be less than 0·2 and 0·6 per cent respectively. He emphasised that this statement should not be taken too literally, and he hoped that nobody would ever think in terms of those figures when it came to specifications.

On page 12 of the paper, at the end of the first column, reference was made to sub-critical annealing, and a little later it was stated that spheroidisation was produced at 650 deg. Cent. This was something which was to be avoided. If one was going to use a temperature of 650 deg. Cent. it should obviously be kept to a minimum.

Dr. N. P. Allen said that the work summarised in the paper had always been considered by the Department of Scientific and Industrial Research as of great importance in the long-term economy of the country, and had been given high priority for many years in the programme of the National Physical Laboratory. One of the most important results of the work had been the development of accurate methods of measuring creep, and an appreciation of the creep process and the way in which it might be influenced. It was not too much to say that this country's present advantage in the field of aircraft engines was partly due to the fact that when the time had come for the development of gas turbines, the methods of dealing with this kind of problem had been a little ahead of those existing in other countries.

But they had not yet applied this knowledge as vigorously as they might have done to the raising of steam temperatures, with its consequent improvement of thermal efficiency. An effort comparable in intensity with that exerted during and since the war was required, but it seemed certain that large rewards were technically possible.

Experience showed that most materials were subject to considerable varieties of creep strength according to the method of manufacture, and as new materials were introduced each must go through a stage in which it was studied to determine the best condition, and the properties in the best condition were defined. Particular attention had to be given to avoiding such troubles as cracking with low elongation after prolonged service. The amount of work of this kind was considerable. The 0·5 per cent molybdenum steel had been dealt with in detail, and enabled steam temperatures to be carried to 500 deg. Cent. or so, but the steels which must be relied upon when steam temperatures rose to 600 deg. Cent. and above remained to be considered.

The ultimate aim must be to define the least number of economical and practicable steels with which the future working range could be covered, having regard to the need for tubes and pipes, high-tensile bolts, castings for valves and casings, rotors and blades. It had to be remembered, also, that these components had to be fabricated, and sometimes welded, and to be heated up and cooled down. It was important that the smallest number of steels be chosen, and those the best, for the engineer was better served with a few materials that could be relied upon, rather than a number of compositions all of which were unknown quantities.

At present they were finding out what was

the most that could be expected of the molybdenum-vanadium steel in tubes, pipes, castings and rotors, with special reference to steam temperatures around 560 deg. to 580 deg. Cent. and comparing it with the 2¼ per cent chromium, 1 per cent molybdenum steel which was a possible alternative. They were also finding out at which point these must give place to the more costly austenitic steels.

It seemed to be turning out that for the stresses in which they were interested ferritic steels could be made to have low creep rates at quite high temperatures, and that they would fail for lack of oxidation resistance before they would fail for lack of high-temperature strength. Considerable attention was therefore being given to the question whether there was a place for an oxidation-resistant ferritic steel which would serve when the temperature was so high that ordinary ferritic steels oxidised, but the temperature was not so high that austenitic steels were necessary. The introduction of austenitic steels was attended with difficulties, particularly where ferritic and austenitic steels had to be joined, but the solution of the problem of making such joints, and of finding the stresses, could not now be much longer delayed.

If boiler atmospheres contained nothing but clean air, and steam nothing but steam, materials were in sight that would enable steam temperatures to rise to 650 deg. Cent. and above. The greatest anxiety was to know the effects on the materials of contaminants of various kinds operating for really long periods. Laboratory research on the mechanism of corrosion at high temperature would be helpful, but on the practical side the importance of providing good conditions of service and easing the burden on the material could not be overstressed.

Mr. W. Barr said that much of the review dealt with the conclusions drawn from the experimental work, and the author had made a valiant attempt to condense all those conclusions into a limited volume. However, there were a number of points which were liable to misinterpretation, and it was essential that they should be corrected.

It was now well established that "abnormal" creep resulted from large additions of aluminium during manufacture. It so happened that aluminium killed steels were almost invariably made in the basic open-hearth furnace, but this did not mean that the process was in any way inherently unsuitable for making creep steels of the highest quality. Similarly, a high aluminium steel usually had a low silicon content, so that many of the low silicon steels mentioned in the paper had poor creep properties. It was, however, quite wrong to deduce that more than 0·2 per cent silicon was necessary to ensure that a steel had good creep properties. What was necessary was to ensure that the steel was not killed with excess aluminium. In fact, there was some evidence to suggest that a low-silicon steel was better than a high-silicon steel for long-time service. Another fact which tended to make the high-silicon steels better in the reported tests was their high manganese content. In this connection, there appeared to be a slight slip up in the text of the paper, since it was stated that the high-silicon steels had a low manganese content, whereas reference to the detailed results published previously showed that the contrary was the case.

In the section of the paper dealing with "abnormal" creep, it was stated that slow cooling from 1100 deg. Cent. gave a finer grain size than fast cooling. Again, this was contrary to the results already published. Moreover, the N.P.L. work showed that grain size *per se* did not cause "abnormal" creep, and that the real explanation had not yet been discovered.

Mr. P. H. Margen, said that the paper dealt with one portion of the terms of reference of the J/E Committee, i.e. providing the design data. There was a second very important portion of the terms of reference, i.e. to give information on how those design data should be used for determining allowable stresses. He did not think there had been an official pronouncement on this, although a number of rules had been proposed by individual investigators, and all of them differed to some extent.

One rule was to design for a given creep strain of 0·1 per cent, 0·2 per cent or 0·5 per cent ; a second rule was to design for a creep strain which was a given fraction of the elongation of fracture, and a third rule favoured in the U.S.A. was to design for a fraction of the stress to produce fracture in the life of the plant. He thought that all these simple rules were inadequate as a universal basis of design.

Dr. J. S. Blair said that it seemed to him that there were a number of statements in the paper which required some amplification. One of them was to the effect that Hooke's Law was not a suitable basis for design. He reminded the author that, in fact, it was the basis of design at the moment in this country and in every country in the world. It might well be wrong, but it was the basis. He would like to know whether the author or the committee had anything to suggest as an alternative.

The use of the formula based on Hooke's Law or anything else was tied up with the stress that was going to be used in that formula, and he agreed with Mr. Margen that something ought to be done in the way of making a decision as to what was the right basis—whether so much per cent creep or rupture, and, if either of those, what type of factor of safety or allowance should be made for the stresses that produced those figures.

He suggested that there were really two different aspects. Most of the paper, although it was entitled "Steels for Steam Power Plant," was dealing largely with the pipework and the superheater tubes of steam power plant rather than the turbines or the bolts, and there were two quite different aspects of creep. If the total amount of elongation that took place during the service of the part mattered, if that must not be more than a certain amount, then there was quite a different picture from the case of, say, a steam pipe. Did it really matter if a steam pipe were to swell 1 or 2 per cent ? It made a lot of difference to a bolt ; by the time it had extended 1 or 2 per cent it had lost all its purpose. But a steam pipe which expanded 1 or 2 per cent at most let through a little more steam. If it did not burst, that did no harm. There were two different criteria—one for cases in which dimensional changes mattered, and the other for cases in which they did not matter, and in that second category it was probably rupture which was the right basis. He thought this point was worthy of further consideration.

He noticed that the author said that relaxation tests could not be deduced from tensile tests. In that matter he must admit to being a little sceptical, and he wondered whether the author could amplify why he could not deduce the one from the other.

The author referred at one point to the cold drawing of steam pipes as though, in fact, steam pipes were cold drawn in all cases. That was not true. Some steam pipes were, but the vast majority of them were not.

Mr. A. M. Sage, in a brief reply to the discussion, dealt with one or two small points and said that he would give a full reply in writing.

Symposium of Papers on Insulating Materials

A SYMPOSIUM of papers on insulating materials was presented at meetings of the Measurements Section of the Institution of Electrical Engineers in London on March 16th, 17th and 18th. The purpose of the symposium was to review recent advances in the science and technology of electrical insulating materials and to survey modern trends in the insulation of electrical equipment. For convenience of presentation the thirty-two papers comprising the symposium were divided into five sessions, each of which was introduced by a rapporteur. The proceedings began at 5.30 p.m. on Monday, March 16th with a short opening address by the president of the Institution, Colonel B. H. Leeson, who said that the symposium would be a fitting sequel to the earlier symposium on magnetic materials, organised by the Measurements Section of the Institution in 1949. He thought that it was instructive, in assessing recent progress, to look back from 1953 to 1890, when the historic Ferranti cable, insulated to work at 10kV, was laid between London and Deptford. Looking ahead, the president believed that it was desirable to know more about the "strength" and "durability" of insulating materials and thus to be able to predict their life with confidence. In this connection quality control could play an important part.

The first session of the symposium was under the chairmanship of Dr. L. Hartshorn and the subject matter was covered by six papers dealing with permittivity and dielectric losses in solids. To introduce the subject for discussion, Professor Willis Jackson, acting as rapporteur, gave a short appraisal of the papers. Permittivity and dielectric losses in liquids formed the theme of the five papers discussed in the second session, which was held on Tuesday, March 17th, at 2.30 p.m., under the chairmanship of Mr. J. F. Coales. The rapporteur for this group of papers was Dr. L. Hartshorn. The evening session on Tuesday was devoted to the discussion of ten papers dealing with electric strength and breakdown mechanisms. Mr. M. Whitehead was chairman and Dr. S. Whitehead, in the capacity of rapporteur, gave a short appreciation to introduce the papers.

The fourth session opened at 2.30 p.m. on Wednesday, when the chair was taken by Dr. S. Whitehead and eight papers concerned with the general properties of insulants and current problems were introduced by Dr. R. W. Sillars. Abstracts from one of these papers, "The Properties of Some of the Newer Laminated Plastic Insulating Materials," are reproduced on page 436 of this issue.

The final session, which was at 5.30 p.m. on Wednesday was concerned with three papers covering various aspects of the classification, specification and testing of insulating materials. The chairman for this session was Dr. L. Hartshorn and the rapporteur was Dr. T. E. Allibone.

The papers, together with the discussions and authors' replies making up this symposium, will be published later in a special issue of the Institution's *Proceedings*, Part IIA, No. 3.

FLOOD DAMAGE TO INDUSTRIAL PLANT.—At a recent meeting of the London and South-Eastern Regional Board for Industry, a report was received from the Board of Trade on the flood damage to plant, fixtures and stock at industrial establishments in the region. It was stated that nearly all the firms which had been affected by the flooding were now more or less back to normal working, but that the loss of production on export orders and also defence work, due to damaged plant, fixtures and stock, as well as to delays caused by dislocation of normal routine in the workshops, had still to be fully assessed. Officers from the Ministry of Supply had visited firms which suffered in the floods in order to prepare a comprehensive report of the effects of the disaster on production and employment. Problems to be faced in rehabilitating industry in the districts badly affected by flood were fully discussed at the meeting. Concern was expressed at the effects on productivity and employment of the damage to plant, fixtures and stock and the substantial financial loss for a large number of firms.

The "Nomad" Compounded Diesel Engine

In the "Nomad" engine a twelve-cylinder, two-stroke diesel engine is compounded with a turbine compressor set. This exhaust-driven set is used to supercharge the diesel engine and has also a power turbine which is mechanically coupled to the diesel engine. It has a fuel consumption of between 0·33 lb and 0·35 lb per e.h.p. and a power/weight ratio of 0·875. The engine first ran in 1951 and the modified engine discussed below is now on bench tests.

LAST week D. Napier and Son, Ltd., was able to release some further details of the "Nomad" compounded engine, and to illustrate the advantages which are claimed for this particular engine. The "Nomad" was designed to provide an aero-engine having the lowest practicable fuel consumption under any operating conditions. This was achieved by compounding the simplest form of two-stroke diesel engine with a gas turbine, and transmitting the power through a propeller. This kind of engine also enables a wide range of fuels to be used, such as diesel fuel, kerosene and wide-cut gasoline. The low fuel consumption, which is made possible by the combination of the diesel engine with a gas turbine, is achieved by the use of higher compression and expansion ratios than are used in the pure gas turbine cycle.

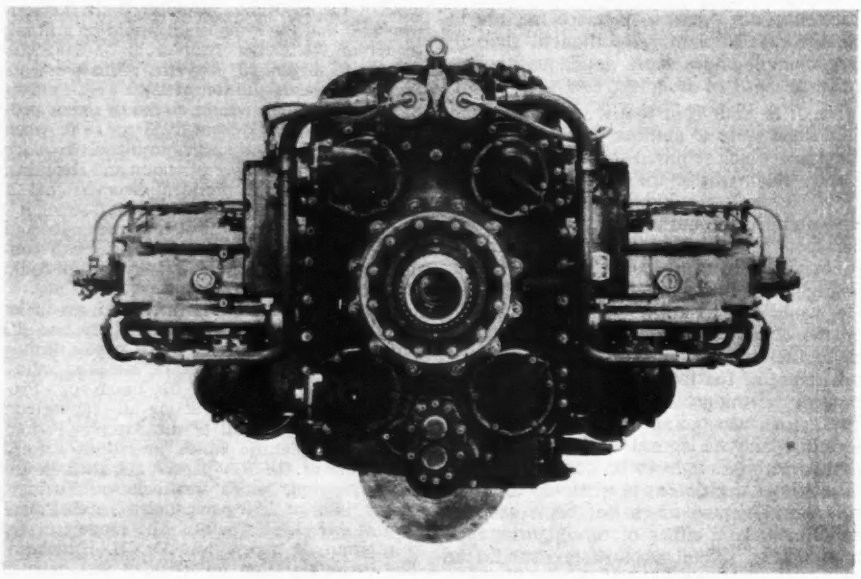


Fig. 1—Rear View of the "Nomad" Compounded Diesel Engine

The "Nomad" consists of a simple two-stroke diesel engine, to which is added a turbine compressor set. The axial-flow compressor is on a common shaft with a multi-stage exhaust turbine, and the turbine compressor set thus formed is coupled mechanically to the compression-ignition engine through suitable gearing. The power of the compression-ignition engine and the surplus power available from the exhaust gas turbine are transmitted to a common single rotation propeller shaft by a reduction gear in the nose of the engine assembly. The "Nomad" is controlled by a single pilot's lever.

One of the chief characteristics of the "Nomad" engine is the low specific fuel consumption which it can maintain over a wide range of altitudes and speeds. This consumption remains between 0·33 lb and 0·35 lb per e.h.p. per hour. It can operate equally efficiently on kerosene, diesel fuel or wide-cut gasoline, without modification. The engine weighs 3580 lb and develops at sea level a take-off power of 3135 e.h.p.

The engine illustrated in Figs. 1 and 2 differs from the original prototype in several important respects. The development of axial compressors since the design was first conceived has enabled the high compression ratio to be obtained with a single axial compressor without the assistance of a supplementary centrifugal blower, as was included originally. Another important change can be noted by the fact that a single propeller shaft is employed. Formerly the turbine and the diesel engine drove coaxial shafts. Consequently it has been possible to shorten the engine by 3ft 6in and to achieve an overall reduction in weight.

In some notes issued by the company the relative performance of three hypothetical aircraft is compared. These aircraft are powered by turbo propeller, turbo jet and "Nomad" engines respectively, and it will be noted from the following table that the capacity payload for each aircraft (over a still air sector distance of 2860 statute miles) is the same.

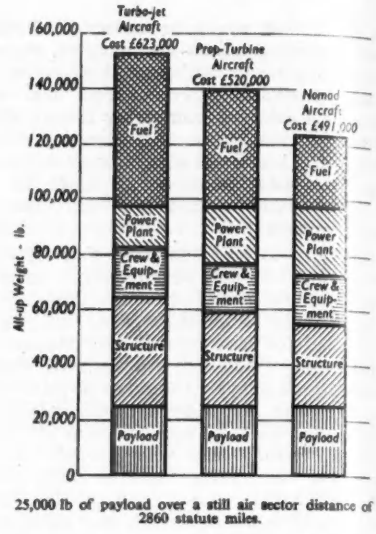


Fig. 3—Aircraft All-up Weight and Cost for a Given Duty

Aircraft Data Sheet

	"Nomad"	Prop-turbine	Turbo-jet
Take-off power... ...	12,540 e.h.p.	15,120 e.h.p.	40,000 lb thrust
Span, ft	132	140	123·5
Wing area (gross), sq ft	1,840	2,050	2,185
Aspect ratio	9·5	9·5	7·0
Length overall, ft ...	114	114	114
Fuselage diameter, ft	12	12	12
Volumetric capacity payload, lb	25,000	25,000	25,000
Aircraft basic equipped weight, lb	71,000	70,000	70,370
Aircraft all-up weight, lb	123,500	140,000	153,000

On this basis of a common payload and range the influence of the much lower fuel consumption of the compounded engine upon the overall size, and hence the cost of the aircraft, is shown in Fig. 3. It will be seen that, although the weight of the power plant is heavier, a reduction in structure weight is possible due to the much lower fuel load.

The actual cost of fuel is the largest individual item in the direct operating cost of an aeroplane. Furthermore, for a given capacity payload and range an aircraft earning efficiency is impaired by all contingencies for which allowances have to be made, such as head winds, navigational errors, holding time and diversions.

The advantages of the lower specific fuel consumption of the "Nomad" engine and the

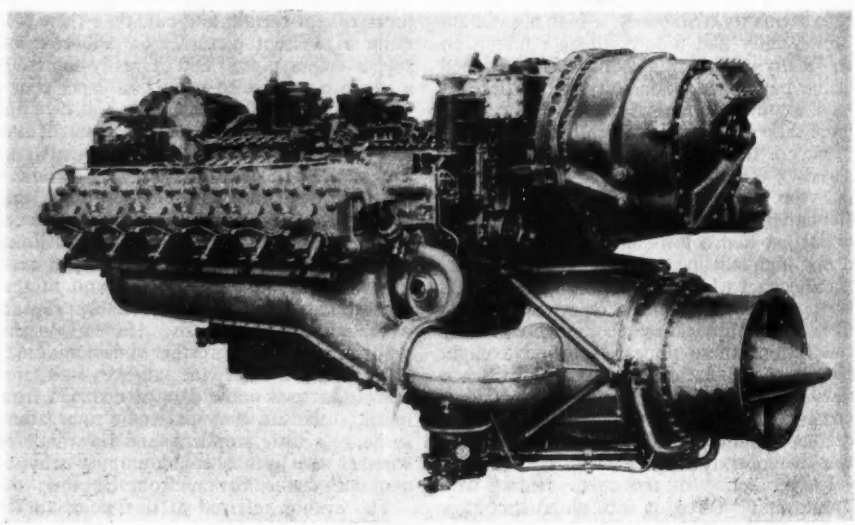


Fig. 2—The "Nomad" Compounded Diesel Engine

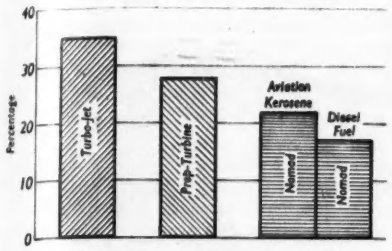


Fig. 4—Fuel Costs as Percentage of Direct Operating Costs

cheaper fuel consumed is shown graphically in Fig. 4. On a particular route, such as the London-Bahrein (3150 miles), the influence of fuel cost on the direct operating costs is indicated in Fig. 5. Similarly, the effect of fuel reserves on payload is shown in Fig. 6, where it can be seen that when the same aircraft are operating on the London-Bahrein sector, the fuel reserves with the compounded engine amount to only 14 per cent of the capacity payload, against 24 per cent for the propeller turbine aircraft, and 37 per cent for the turbo-jet aircraft.

Fig. 7 shows the cost of these fuel reserves and the cost of the total fuel carried by the three aircraft. For the sector considered (London-Bahrein) the propeller turbine aircraft uses 62 per cent more fuel and the turbo-jet aircraft 120 per cent more fuel than the " Nomad " aircraft, when each aircraft is running on aviation kerosene

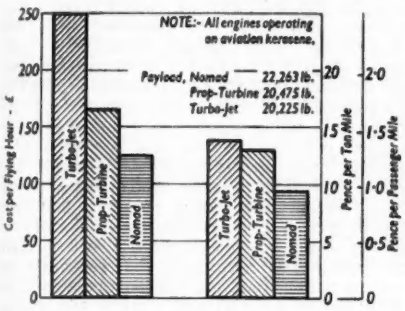


Fig. 5—Direct Operating Costs for London—Bahrein Sector (3150 st. miles)

fuel. Running the " Nomad " on diesel fuel further increases this advantage as shown.

Some of the advantages obtainable with long-range operations are recalled by the company with regard to the comparison of these hypothetical aircraft. In the first place, it permits regularity of operation against a wide variety of head winds and weather conditions. Secondly, it is of great benefit psychologically to the pilot, since it opens up a much greater number of aerodromes which can be reached with a given payload. Thirdly, it provides considerable economy in operation by avoiding the necessity of station maintenance and operational personnel, spare parts, and refuelling facilities at intermediate landing points. Also, because of the possibility of mechanical defects being found or occurring while the aircraft is on the ground, and the chances of the weather deteriorating in such a manner as to prevent a take-off, greater regularity will be achieved if intermediate landing

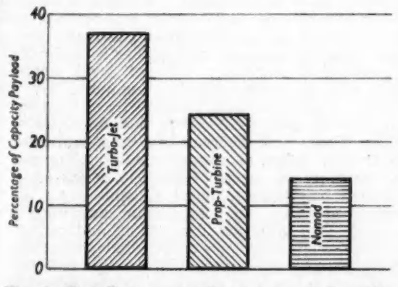


Fig. 6—Fuel Reserves as Percentage of Capacity Payload

points are avoided. In addition, the chances of a diversion somewhere along the route are increased in proportion to the number of intermediate landing points.

The cumulative effect of these factors tends to neutralise the speed advantage which one aeroplane may have over its competitor if the latter has the longer range necessary to permit a particular sector to be flown non-stop. Fig. 8 gives an illustration of this for the London to NewYork sector. D. Napier and Son, Ltd., says that no jet-engined civil transport yet constructed is capable of flying this sector non-stop regularly during the winter months. Gander, which lies on the direct route from London to New York, has been chosen as an

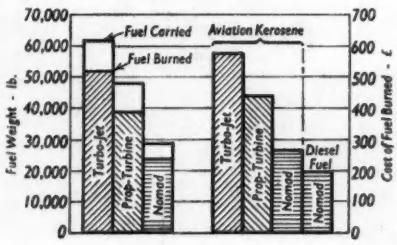


Fig. 7—Fuel Requirements for Sector London—Bahrein (3150 st. miles)

intermediate stopping point, although it is equally likely that some other aerodrome, such as Goose or Montreal, which is not on the direct route, might have to be used. It will be seen that the pure jet aeroplane completes the journey from London to New York in ten hours elapsed time, whereas the " Nomad " powered aeroplane, which can fly non-stop, but whose cruising speed is 180 m.p.h. less, only takes 11·7 hours. Against this the " Nomad " powered aeroplane would have the advantages in economy and regularity outlined above.

In reviewing the landing characteristics of these aircraft the company refers to the influence of aerodynamic drag factors upon the circuit speed and the landing run. It is pointed out that,

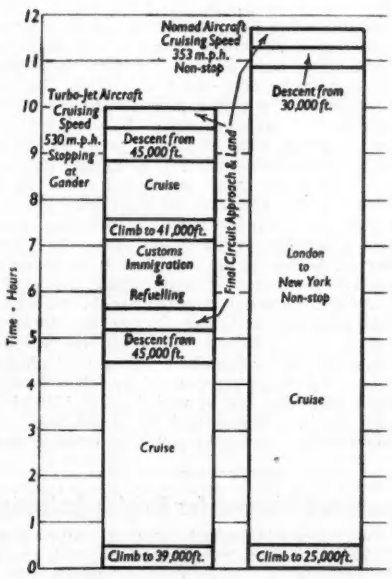


Fig. 8—Elapsed Time London—New York

in order to slow a jet aircraft down in the approach configuration, it is necessary to resort to a number of high drag devices, and in order to bring it to a stop in an acceptable distance special methods of retardation, such as tail parachutes, have to be employed. Even so, the landing distances required are very dependent on the accuracy of the pilot in maintaining the prescribed speeds. The I.C.A.O. landing distance regulations require the aeroplane weight and performance at landing to be such that it can be brought to rest within 60 per cent of the available runway length. This is a severe requirement and is already proving critical for jet transports.

With a propeller, however, it is possible to reduce the landing run by means of reverse thrust, and the aerodynamic drag in the idling position also plays its part in reducing the landing run. Furthermore, because a propeller-driven aeroplane will generally be lighter and smaller than the jet aeroplane carrying the same payload, the advantages of the propeller-driven aeroplane in low approach speeds should, the company suggests, permit reduced weather minima and, in consequence, regularity of operation will be increased without employing braking propellers or tail parachutes. The design figures provided by the company indicate that the " Nomad " aircraft would require from 1200 yards to 1900 yards runway length when landing with from 60 to 90 per cent of its all-up weight, against the turbo-jet aircraft requirements of from 2000 yards to 3400 yards.

The performance of this form of compounded engine is also less adversely affected by operation away from its optimum altitude than is the turbo-propeller and particularly the turbo-jet aircraft. The specific fuel consumption of the " Nomad " is

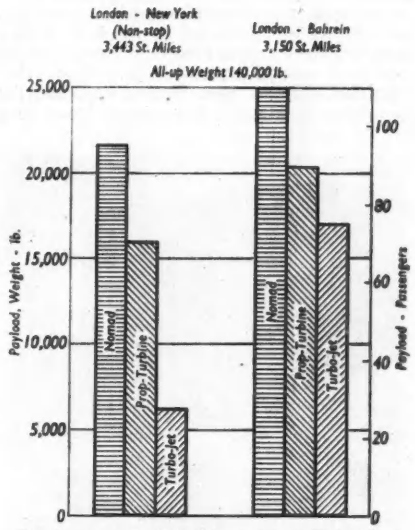


Fig. 9—Aircraft of the Same All-up Weight and Varying Payload. (All-up weight 140,000 lb.)

also much less sensitive to ambient temperature changes than the jet and the propeller turbine, which both suffer from significant deterioration in performance with increases in ambient temperature. As a result, aircraft powered by such engines require long runways for take-off in high temperature areas, where, because of the low traffic density or the inadequate financial resources of the community concerned, the building of long runways is difficult to justify. In consequence, operating weights must be reduced because of the runway lengths available.

As compared with its sea level I.C.A.N. performance the " Nomad " loses only 2½ per cent of its equivalent horsepower for a temperature rise of 15 deg. Cent., whilst both the turbo-jet and propeller turbine lose approximately 9 per cent under similar conditions.

The previous comparisons have related to aircraft designed to carry 25,000 lb over a sector length of 2860 statute miles. In order to achieve this carrying capacity the all-up weight of the three aircraft must reflect the fuel consumption of the three kinds of engine, with the result that whereas the " Nomad " version has an all-up weight of 123,500 lb, the propeller turbine and turbo-jet versions have all-up weights of 140,000 lb and 153,000 lb respectively.

Fig. 9 shows the effect of using the same all-up weight (140,000 lb) for each aircraft. It will be seen that over the two sectors considered the payload which can be carried varies very considerably with the form of power plant, and the low fuel consumption of the " Nomad " offers a significant advantage. The payload carried on the London-Bahrein sector can be compared

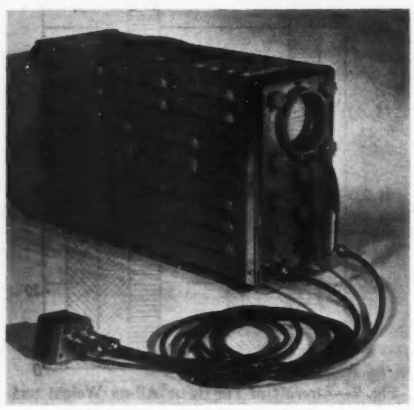
with Fig. 5, in which different all-up weights have been assumed for the three aircraft.

It will be noticed on Fig. 9 the big difference in payload carried over the London to New York and London-Bahrein routes. This difference arises because on the London to New York route the average effective route wind is a head wind varying from 45 to 60 m.p.h. according to the altitude at which the aircraft is flying, whereas on the London-Bahrein route the average effective route wind is a following wind of 20 m.p.h.

Supersonic Flaw Detector

To satisfy a demand for a supersonic flaw detector, which would be readily portable and of a size suitable for use in spaces to which access is very much restricted, Kelvin and Hughes (Industrial), Ltd., has produced the new miniature supersonic flaw detector, Mk. V. This new instrument is expected to be generally available soon and at the invitation of the company we were able recently to inspect the miniature detector and to see it in operation.

It was during the last war that the company developed an apparatus for crack detecting by use of a very short pulse concentrated into a narrow beam. By its use hair-line cracks could be detected at a range of several feet and this early model was followed by the Mk. II flaw detector, which satisfied the requirements of the steel and aluminium industries. Since that time improvements have been effected and the Mk. III and Mk. IV instruments have been



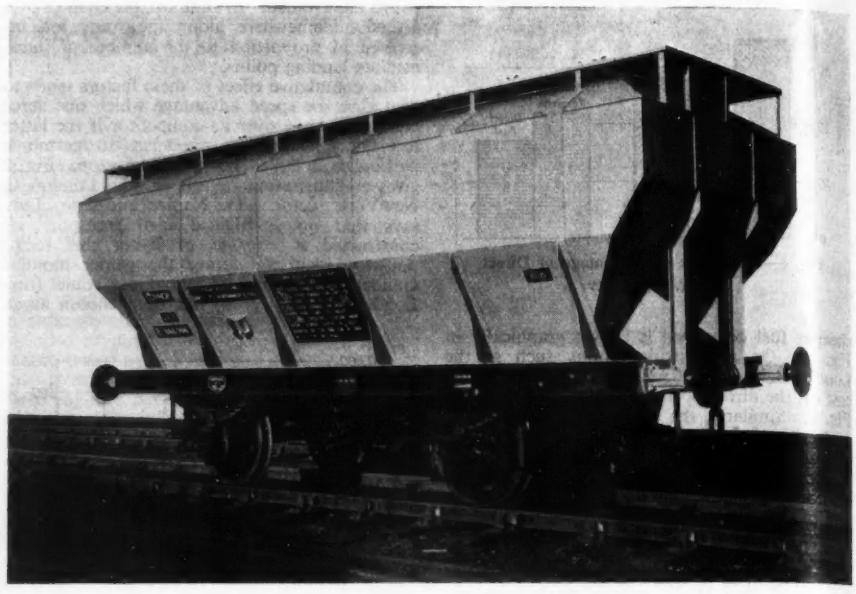
Supersonic Flaw Detector

developed, the Mk. IV instrument being described in THE ENGINEER of September 16, 1949. The latest equipment is the Mk. V, which incorporates the advances of technique and the results of practical experience and extensive research which have taken place during the intervening years.

Ultrasonic flaw detection is now well established and the new model has been specifically designed to pass through small openings, such as manholes, for the purpose of inspecting pressure vessels and welds in places not readily accessible to the existing model. The Mk. V equipment, which we illustrate above, is self-contained and measures 17in by 9in by 5in, while it weighs about 28 lb, compared with the 64 lb of the Mk. IV detector. Such dimensions and weight ensure that the detector can be handled easily and can be used to search for cracks in shafting, crankshafts, castings and forgings, engine castings and welds.

Important factors in the design are that the cathode-ray tube and valves are of standard pattern and that, even on the shortest range, a bright trace, clearly visible in daylight, is achieved. Further, the scale can be expanded so that the width of the screen represents only a part of the full range, thus facilitating thickness measurement or the individual separation of closely grouped flaws. New light-weight leads are included which can be operated with all the Kelvin Hughes probes, including those of vertical, wedge design and the combined transceiver probe, seen in our illustration, which has many of the advantages of the dual probe system while permitting manipulation by one hand. In the latter, acoustically and electrically separated transmitter and receiver crystals are mounted in the exploring head, the receiver crystals being placed on either side of the transmitter crystal. A better performance on rough surfaces than with a single crystal is obtained and the minimum range is approximately $^1/_{10}$in, although special calibration is required for thicknesses of less than $\frac{1}{4}$in when using a depth gauge. The combined probe is available as a vertical probe and as an angle probe for the generation of longitudinal and transverse waves, respectively.

The "Perspex" screen of the detector, which has an engraved scale and is edge illuminated, facilitates photographic recording for which purpose a special camera is available. Another item in the design is the duplication of the coaxial sockets to permit the use of special filters on a thickness gauge. The thickness gauge, which is oil-filled, is connected in parallel with the probe and has two crystals, the distance between which is adjustable, and scales suitable for various metals. It is understood that the gauge, which has an accuracy of 0·01in, has been accepted in principle by Lloyd's Register of Shipping but final approval for its use in measuring the thickness of shell plating, &c., will depend upon the results of practical trials. The instrument operates on 200V to 250V, 50 c/s a.c. mains, but models can be supplied specially for other voltage ranges. A switch selects the frequency required for the particular material under test, the frequencies available being $\frac{5}{8}$, $1\frac{1}{4}$, $2\frac{1}{4}$, $2\frac{1}{2}$ and 5 Mc/s, but intermediate values can be obtained by the use of plug-in filters. The range represented by full deflection of the time base can be varied up to 12ft when using vertical probes and to about half this distance when operating with transverse probes.



24-ton Covered Hopper Wagon

Standard Wagons for British Railways

Two more standard wagons have been introduced on British Railways for specific traffic requirements—a 27-ton iron ore wagon and a 24-ton covered hopper wagon.

The covered hopper wagon, which is illustrated on this page, is designed to meet the requirements of bulk conveyance of chemicals such as soda ash, sodium tripolyphosphates or catalysts. It has been designed to obtain the maximum capacity within a total gross load of 35 tons. The length of the vehicle over buffers is 24ft 6in and the wheelbase is 10ft 6in.

An underframe of special design is arranged to accommodate the hoppers from which the load is ejected between the frames. The body is of welded construction, its roof and sides being built up of $\frac{1}{16}$in mild steel plates, whilst $\frac{1}{4}$in thick plates are used for the ends and the hoppered portion of the body. Tee-sections and gusset plates stiffen the body and are welded to the underframe, the combined body and underframe giving adequate strength and stiffness. A partition divides the body into two compartments and the two hinged doors, 6ft 11in long and 2ft 5in wide, provided in the roof are fitted with rubber weather seals and secured by screwed eyebolts. A roof vent is used with or without valve, according to traffic and a catwalk is provided to give ready access to the filling doors. The wagon interior is flush and the hoppers can be completely discharged by gravity through two sliding doors in each compartment. The opening mechanism fitted for the doors is a rack and pinion operated from either side of the wagon by a removable handle.

In the case of soda ash or sodium tripolyphosphate, a coupling for a detachable vibrator is welded to the sides of the hoppers to assist unloading.

The 27-ton iron ore wagons are constructed for discharging by tipplers. They have a length of 19ft 6in over buffers and a wheelbase of 9ft. For the underframe, which is either of riveted or welded construction, standard rolled steel channels are used for the main members.

The bodies are made of high tensile, low alloy steel $\frac{7}{16}$in thick, or of $\frac{1}{4}$in thick mild steel. No doors are provided in the body, which is strengthened by pressed steel side and end stanchions. The side stanchions are stiffened to accommodate tippler beams.

Book of Reference

Climatological Atlas of the British Isles. London: H.M. Stationery Office. Price £2 12s. 6d.—This volume has been prepared by the Meteorological Office of the Air Ministry, which states that it is the first reasonably complete climatological atlas of the British Isles to be published. The atlas is the result of the collection of the records of weather data made by thousands of climatological observers, and is divided into ten sections, each dealing with one of the climatological elements: pressure, wind, temperature, rainfall, snow, thunder, humidity, fog and visibility, sunshine and cloud. Every section is complete in itself. All except that on cloud have plates of maps and diagrams of average and extreme conditions. Maps of average conditions are mostly for the thirty-year period 1901–1930, selected by the International Meteorological Organisation. Each section also has an introduction describing the methods of making the observations and correcting the data, interesting items concerning extreme values or comparison with long-period averages and, where necessary, tables and diagrams to supplement the plates. Information about the plates and a bibliography are included in the sections.

"Avon" Turbo-Jet Developments

AFTER the recent statement that an "Avon RA.7" turbo-jet had passed a 150-hour type test at a basic rating of 7500 lb thrust, it has now been announced that a 150-hour type test has been completed on an "Avon RA.7R" engine equipped with reheat at a gross rating of 9500 lb thrust.

Rolls-Royce, Ltd., states that one of the most favourable ways of increasing the thrust of a jet engine is by means of reheat. By introducing additional fuel into the tail pipe the average jet stream velocity and hence the jet thrust can be considerably augmented without increasing the engine frontal area. Although there are several small penalties associated with the use of a reheat system, it is a most practical way of thrust boosting at high speeds and is almost essential for supersonic flight. It is on this question of aircraft speed that reheat scores most heavily over other methods of thrust augmentation. A system which can provide 25 per cent gain at take-off conditions will produce nearly 50 per cent at 700 m.p.h. and over 65 per cent at 1000 m.p.h.

Reheat also provides a useful thrust boost for take-off, if necessary, and will almost halve the time to climb to the aircraft service ceiling for almost the same expenditure of fuel. It will very considerably raise the maximum altitude at which a fighter can operate, and will improve its manœuvrability. However, as the overall fuel consumption is much higher, reheat must be limited to short duration. But the company maintains that it remains the most economical means of thrust augmentation.

Other "Avon" Developments.—Thrust output figures may not be given for all "Avon" engines, but it is of interest to note that development of the "RA.2," "RA.3," "RA.7," and "RA.7R" (reheat) engines has resulted in an 8 per cent, 15 per cent and 27 per cent thrust increase in four years.

Although no details may be released, two further "Avon" engines may be mentioned; these are the "Avon RA.14" and also a civil engine of 9000 lb thrust. Although total weight has been increased on the "RA.7" engine as a result of strengthening to meet the loads imposed at sonic speeds on fighter aircraft, the thrust to weight ratio has continued to improve.

This progressive improvement in performance is part of the history of "Avon" development, about which only a few details may be released. These developments have their parallel in the "Merlin" engine, which, under the incentive of war, increased in power in ten years from 900 h.p. to over 2000 h.p. while more than fifty-two versions of the basic "Merlin" engine were manufactured. This was achieved by the Rolls-Royce practice of closely relating development to production, a policy which is being continued with the "Avon" engine.

Marks of "Avon" Engine.—In the Rolls-Royce group of factories nine different marks of "Avon" are being manufactured, seven of them being of "RA.7" rating and the remaining two of "RA.3" and "RA.9" rating. As with the "Merlin," these variants of the basic "Avon" engine have been developed for fighter, bomber, naval and civil aircraft.

The "RA.7."—When development testing started on the "Avon" engine, performance prediction was conservative, the experimental "RA.2" engine having a rating of only 6000 lb thrust, later raised on the "RA.3" to 6500 lb. Quantity production of the "Avon" began in June, 1950, and a start was made with the formation of an R.A.F. "Canberra" squadron in May, 1951.

In parallel with the production of the "RA.3," further development was carried out on the "Avon" to meet fighter aircraft requirements, to incorporate full anti-icing, to introduce reheat and to bring it up to the "RA.7" rating of 7500 lb thrust. Engines of this rating were flown at the S.B.A.C. flying display in 1950, 1951 and 1952. A "Canberra" was also flown powered by two "Avon" reheat engines.

Six months after the completion of the "RA.7" type test in March, 1952, deliveries had started to aircraft constructors. Meanwhile development work continued on reheat for the "RA.7R" engine, which successfully passed its type test in January, 1953.

Anti-Icing Systems.—Whilst performance was being increased development was proceeding on anti-icing, an essential requirement for engines having such a mass air consumption as the "Avon." Bench and flight development testing of the anti-icing system has now been completed and will be included in the specification for production "RA.7" engines as from this month. The "RA.7" engine with the new details will be produced for certain of the latest R.A.F. operational aircraft, as well as for some of the latest Australian-built fighters and bombers. The "RA.7" will also be manufactured under licence overseas.

Since its first flight in a converted "Lancastrian" over 40,000 flying hours have been accumulated in addition to many thousands of hours of test bed running.

The North of Scotland Hydro-Electric Board's Annual Report

THE annual report of the North of Scotland Hydro-Electric Board for the year 1952 has now been published. The Board made a profit of nearly £5000 during the year, and spent about £13½ million on capital works, bringing its total capital expenditure up to the end of the year to about £83 million. The accompanying table gives details of production and capacity of the Board's power stations over the past four years, and also gives some details of distribution costs. The distribution of power to possible consumers within its area is an important part of the Board's work, and half of the possible consumers who had no supply in 1948, when the Board started large-scale distribution, have now been connected to the Board's mains. The peak demand in the Board's area reached 275MW in December last.

During 1952 hydro-electric plant with a capacity of 26·5MW was brought into operation at the Affric, Gairloch, Lussa and Storr Lochs schemes, the Affric scheme being formally opened by H.R.H. the Duke of Edinburgh on October 13th. The small power station at Loch Luichart, which was built in 1928 and had an installed capacity of 2750kW, was closed down during the year to enable constructional work to be started for the new Luichart scheme. Three new constructional schemes—amendments to the Moriston scheme and extensions at Cowal and Lussa—were published during the year, together with a scheme for transmission lines connected with the Breadalbane scheme; the Kilmelfort scheme and four main transmission schemes were passed by Parliament. Schemes under construction and in course of promotion at the end of the year had total installed capacities of 287MW and 416MW, respectively, and estimated annual outputs of 828 and 1477 million units, respectively.

Power Statistics of the North of Scotland Hydro-Electric Board

	1949	1950	1951	1952
Hydro-electric power :				
Capacity, MW	87	285	368	391
Units generated, kWh × 10^6	322*	522	702	889
Steam power :				
Capacity, MW	131	131	132	131
Units generated, kWh × 10^6	320	284	318	296
Diesel power :				
Capacity, MW	33	37	39	38
Units generated, kWh × 10^6	68	72	61	52
Units sold :				
Units sold in Board's area, kWh × 10^6	511	587	665	727
Units sold to British Electricity authority, kWh × 10^6	56	136	235	304
Units sold in the construction of hydro-electric schemes, kWh × 10^6	27	19	16	20
Total units sold, kWh × 10^6	594	742	916	1,051
Units used in generating stations and lost in transmission and distribution, kWh × 10^6	116	136	165	186
Total units generated, kWh × 10^6	710	878	1,081	1,237
Average price paid per unit by consumers, pence	1·416	1·402	1·411	1·498
Distribution costs :				
Number of new consumers	18,797	22,140	18,861	19,897
Capital expenditure on distribution, £ × 10^3	1,911	2,693	2,863	3,292
Average cost per consumer, £	102	122	152	165

* The production in 1949 was almost entirely from the former Grampian Company's pre-war Rannoch and Tummel schemes.

The work of bringing additional water to the storage reservoirs of the Sloy, Fannich, Cowal and Lussa schemes continued during the year and the catchwater aqueducts of the Sloy scheme were completed in the autumn, the scheme now being supplied by the full 31 square miles of catchment. A start was made in the spring on the upper part of the Moriston scheme, and the small Loch Dubh scheme in Ross-shire was started in the autumn. Work continued on a large scale on five major schemes—Garry, Errochty, Shira, Lawers and the Glascarnoch-Luichart-Torr Achilty scheme.

A number of technical developments mentioned in the Board's report, such as the proposal for an underground power station in the Moriston scheme and the use of the Trief process for the dams of that scheme, have already been noted in these columns. We have also noted at various times the increased rates of progress which were being obtained with new tunnelling methods. During 1952 11 miles of rock tunnels were driven for the Board, the total length of such tunnels driven since the Board started its work being 50 miles; a further 32 miles of tunnels are still outstanding. In one 10ft diameter tunnel the average rate of driving in 1952 was 540ft per month, and in one 16ft diameter tunnel it was 372ft per month; the average rates for such tunnels in 1946–49 were 295ft and 170ft per month, respectively. The improvement is attributed to the "Swedish" drills and to the greater skill and experience gained by the contractors. The Board also experimented with a "Calyx" drill, which was found to be only moderately satisfactory for boring in contorted schist, which was fissured and lying at an angle, but it gave a satisfactory performance on the surge shafts at Invergarry and Quoich.

The principal transmission extension brought into operation during the year was the line from Tummel Bridge to Loch Sloy and the main work in hand was the line from Boat of Garten to Aberdeen. The Strathleven-Kepculloch scheme was nearly complete at the end of the year.

As regards research and development, a 12MW gas turbine was installed at Dundee, and work on the burning of peat in such machines continued, as did other investigations, such as those into hay-drying, wind power and electrical fish screens. Apart from the Board's extensive distribution schemes to villages and hamlets, thirty-one industrial consumers were given a supply of electricity for the first time in 1952.

The Need for Engineering and Scientific Technologists

ON Monday last, March 16th, a meeting was held by the Old Centralians at the Unwin Building in South Kensington, at which the question "How can the future needs of the country for engineering and scientific technologists best be met?" was discussed by a number of speakers. The discussion continued for several hours, and many valuable points were put forward by the various speakers during the course of the evening. The decision announced recently to expand the facilities of Imperial College was favourably commented upon by several speakers and was well received by the meeting, whilst one other point which was made prominent was the need for adequate recruitment of boys into professional engineering, which called for an appreciation on the part of parents and masters of the duties and status of the professional engineer. The first speaker was Sir Arthur Fleming, who commented upon the needs of that branch of industry dealing with the manufacture and operation of electrical plant and equipment. Sir Frederick Handley Page spoke next, pointing out the classes of employees required in the "upper levels" of industry, and the qualities called for in its senior staff. He thought that a variety of training systems was necessary to meet the different needs of different industries, and it would be inexpedient not to use all the available resources for education; he also discussed the content and sequence of training, and the quality of teaching. The third speaker was Mr. H. J. B. Harding, who spoke from the point of view of both a civil engineer and a civil engineering employer, pointing out that a civil engineer had to acquire "a habit of mind backed by laboriously acquired experience."

THE ENGINEER

Vol. 195 MARCH 20, 1953 No. 5069

LEADING ARTICLES—
Engineers and Mathematics 426
Alloy Structural Steels... 426

ARTICLES—
Atmospheric Pollution in London 409
"Avon" Turbo-Jet Developments 425
Breadalbane Hydro-Electric Scheme... 434
British European Airways Docking Facilities. (Illus.) 433
Car Parking in London 409
Chesapeake Bay Bridge. No. II. (Illus.) ... 417
Design of Wheels for Electric Overhead Travelling Cranes. (Illus.) 429
Development of a Marine Steam Turbine Design. No. II. (Illus.) 439
Electronic Thermostat. (Illus.)... 437
Flexible Drive Machine. (Illus.) 440
Heating Metals in Suspension in an Electro-Magnetic Field. (Illus.) 431
Improvements in Ship Performance 430
Institute of Marine Engineers' Annual Dinner... 409
Liverpool Steam Ship Owners' Association ... 434
Need for Engineering and Scientific Technologists... 425
Newer Laminated Plastic Insulating Materials... 436
"Nomad" Compounded Diesel Engine. (Illus.) 422
North of Scotland Hydro-Electric Board's Annual Report 425
Post-War Works of the Port of London Authority 409
Silicones for the Electrical Industry 434
Soil Failures in a Railway Cutting. No. II. (Illus.) 414
Speeding-Up of Summer Train Services on British Railways 409
Standard Wagons for British Railways. (Illus.) 424
Steam Turbine Research and Development. No. II 435
Steels for Steam Power Plant 419
Supersonic Flaw Detector. (Illus.) 424
Symposium of Papers on Insulating Materials... 421
Water Power in the Italian Alps. No. VI. (Illus.) 410

LETTERS TO THE EDITOR—
Engineers and Steel Castings 428
Dimensions on Drawings 428

LITERATURE 427
Books Received 429
Short Notices 428

NEWS AND NOTES—
Books of Reference 424
British Patent Specifications. (Illus.) 443
British Standards Institution 433
Forthcoming Engagements... 444
Indian Engineering News 438
Industrial and Labour Notes 441
Launches and Trial Trips 442
Notes and Memoranda 442
Personal and Business... 442
Technical Reports 444

ENGINEERS AND MATHEMATICS

We have consistently argued for very many years that engineering education should be broadened in scope and to-day there are signs—such, for instance, as the mutual arrangements now in existence between the Imperial College and the London School of Economics and the inclusion by certain universities of management and production studies in their courses—that means are being found of giving students and graduates a broader conception of the work of engineers. There is, however, another way in which present-day syllabuses may be held to be open to criticism. Over the last half-century or so emphasis has increasingly been laid upon the equipment of students with mathematical skill—and rightly so. Yet we wonder, now, whether that emphasis has not been carried unnecessarily far, whether in fact the number of mathematical examination hurdles a student is expected to jump on his way to graduation may not be effectively excluding from the ranks of professional engineers a number of men who, despite their lack of high mathematical ability, could still have become fine engineers. For how important in reality is mathematics to the majority of engineers? In academic life there can be no doubt about the answer, and, again, research workers in very many fields would be very severely hampered without high mathematical attainments. In design, too, though there are other even more desirable qualities, some of them as much artistic as scientific, the ability to use mathematics is very desirable. But relatively few graduates become professors, research workers, or designers. Much larger numbers find their life's work in production and in maintenance and very many of them increasingly discover as they grow older that their problems are as much administrative as technical. Can it really be maintained that engineers in those great fields require so high a skill in the use of mathematics as university courses in engineering attempt to give them?

Fifty years and more ago engineers undergoing training in the works were expected to acquire a skill in the use of tools comparable with that of the men on the shop floor. We do not think they are expected to do so to-day. Instead, their practical training is designed to give them a wide appreciation of the many differing skills required in production and an understanding of what can and cannot be done by skilled work. Surely, here, a comparison can be drawn between practical skill and mathematical skill. The conclusion may then be reached that a trained engineer should be taught enough of mathematics to appreciate what a really skilled mathematician can and cannot do, and to appreciate also his own limitations so that when something important is to be calculated he will know when to call in the expert practitioner! Mathematical skill is not only not easily acquired by those lacking the flair for it; it is not even necessarily helpful in meeting problems encountered in later life to have received a training in its higher reaches. For mathematics cannot be applied until a problem has been properly formulated. When, for example, a crop of unexpected failures of some machine occurs, ability to calculate must wait upon the assessment by experienced engineers of the possible causes and upon the exercise of good judgment in deciding upon reasonably accurate assumptions upon which to base the mathematical investigation. Moreover, should experiment be necessary, extraneous factors such as time available and estimated cost must influence the decision whether to proceed by "trial and error" methods designed to reveal a solution to the particular problem, or whether to start a fuller scale research intended to yield a "general" solution applicable over a much wider field. In fact, since problems can always be submitted if necessary, to those of high mathematical attainments, it is more important that an engineer shall have good judgment and a critical mind than that he shall be skilled in mathematics.

Let it not be supposed that we are here attempting to denigrate engineers who have acquired high mathematical attainments. Heaven knows engineering would still be merely a skilled craft, not a profession, without their work! Nor do we undervalue research workers without whose labours progress, confined to "trial and error" experiments, would become terribly slow. Least of all are we trying to elevate the value of the "rule-of-thumb" engineer who relies upon traditional information. Rules of thumb are a very present help in trouble when, as often happens, no other reliable information is available. But those who pride themselves too much upon being practical, express contempt for theorists and researchers, and continue to rely upon rules of thumb when modern research and mathematical theory have provided better answers, merely hold up progress. What we are suggesting is that the bulk of engineers have less need for actual skill in the use of mathematics, as opposed to appreciation of what can be done by mathematicians, than the academic suppose. Our impression, indeed, is that the pendulum has swung too far. At the opening of this century too little insistence was laid upon the mathematical training of engineers; to-day, too much. Those who have the aptitude for mathematics should be allowed—nay, actively encouraged!—to press on with its study. But failure to make the grade into its higher reaches, we suggest, should be no bar to graduation as a trained professional engineer. After all, the curriculum is crowded. Could not the time saved by the elimination of higher studies in that subject, for all but those with aptitude for it, be more profitably employed in other ways?

ALLOY STRUCTURAL STEELS

The recent Cantor Lectures on "The Safety Factor in Construction" were of interest both to metallurgists and to engineers. The first lecture, by Mr. G. A. Gardner, Chief Structural Engineer, Ministry of Works, dealt with some causes of failure of structures, and reviewed the different components which together make up the composite factor of safety generally used in structural engineering. An assessment was attempted of the several contributory factors necessary to guard against the risks arising from false assumptions in calculations, errors in mechanical treatment during manufacture or assembly and abnormal conditions in service, as well as the lesser risk of a deficiency in the strength or quality of the materials of construction. These separate assessments were shown to justify the use of the usual overall factor of safety. Professor F. C. Thompson, in the second lecture, which we printed in an abridged form in our issue of March 6, 1953, mentioned some of the possible, but somewhat rare, defects in quality—surface cracks due to rough machining, surface decarburisation, micro-cracks running between inclusions, &c. The factor of safety, however, was a matter for the engineer alone. The metallurgist's concern should be with the possibiity of making available materials of higher strength by means of which lighter structures could be designed without any modification of the factor of safety.

As an outline of possible methods of improvement which can be brought about by changes in composition, heat treatment or mechanical treatment of structural steels, Professor Thompson's lecture deserves careful attention. Consideration was given

mainly to the properties of materials stressed longitudinally under static conditions, but not without warnings of possible inadequacy of transverse properties and of difficult problems which may have to be overcome in heat treatment and fabrication. The greater part of the lecture was devoted to low-alloy structural steels. In reporting the properties of these in the as-rolled or normalised condition figures were given for the yield point. This would presumably correspond to a permanent extension of 0·5 per cent or more, and does not reveal the fact that the 0·1 per cent proof stress (and still more the limit of proportionality) is, in many cases, very much lower. The partial air-hardening which occurs on cooling after hot rolling is accompanied by a much lower yield strength and impact figure than the steel is capable of giving if tempered at 400 deg. Cent. Many examples could be quoted, but a reference to the work of J. G. Ball and C. L. M. Cottrell* is sufficient to illustrate the effect.

In this connection attention may be directed to Professor Thompson's suggestion that there should be facilities in the works for simple isothermal treatment of rolled sections of structural steels on a commercial scale. This plea appears to be a very reasonable one for a long-overdue development. For many years alloy elements have been used to an increasing extent in structural steels. It has all along been realised that the best properties in the rolled or normalised steel can only be achieved by putting them through a tempering process, and, until that process is provided for, the alternatives are to use the steels in a condition of unduly low yield strength and toughness, thus failing to make full use of the alloy additions, or to sacrifice much of the possible improvement in strength by the use of a very low carbon content. Even so simple a treament would add to the cost of the steel, and cost is always an important factor. Whether the increased yield strength and toughness, leading to further saving in weight, are worth the additional cost per ton of the material is an economic question to be settled jointly by engineers and the makers of structural steels.

* *Journal of the Iron and Steel Institute*, December, 1951, page 321 ; THE ENGINEER, May 30, 1952, page 730.

Literature

Performance of Lubricating Oils. By H. H. ZUIDEMA. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 40s.

THE practice of fortifying lubricating oils with chemical additives received much of its initial impetus from the failure of the first hypoid gears to operate under the desired conditions when supplied with the oils then available. Likewise the successful development of certain highly rated diesel engines was delayed by "ring sticking" until detergent oils were introduced which prevented the formation of hard carbon deposits in the piston ring grooves. In both these cases the operational difficulties were overcome by development of special oils containing additives rather than by progress in mechanical engineering. One may question the wisdom of pursuing developments which necessitated the introduction of special oils. It might have been wiser to have arranged matters so that ordinary oils would have sufficed ; but at least as far as the U.S.A. is concerned, there is no doubt that mechanical engineers have come to depend on the use of special oils and there appears to be no school of thought professing an alternative view. Additives are now used to confer detergency, extreme pressure properties, improvement in viscosity index, oxidation inhibition, freedom from corrosion and formation of sludge and foam. The continued functioning of an engine having become dependent on the performance of a number of functions by the lubricating oil, it has become necessary to speak of "the performance of lubricating oils" as formerly one spoke of the performance of engines. The author's professional attachment to the laboratories of the "Shell" organisation has enabled him to study at first hand the revolution which has taken place in the function and formulation of lubricating oil, and the book represents an attempt to relate the constitution of an oil to its various performance characteristics.

After a somewhat superficial reference to hydrodynamic lubrication the first chapter deals with boundary lubrication. Frewing's work on transition temperature is given prominence in spite of Bristow's demonstration* of the dubious nature of his premises. The modern view that the effectiveness of boundary lubricants such as oleic acid is in the main due to the formation of a soap by chemical reaction at the metallic surface is contrasted inconclusively with the evidence provided by electron diffraction and X-ray techniques of orientation of polar molecules in the boundary film. The various workers who have endeavoured to elucidate the mode of action of extreme pressure lubricants are reviewed fairly. "Chemical polishing" is contrasted with "anti-welding" action and the additives used are divided into six classes according to chemical type.

The five better-known laboratory instruments for testing E.P. lubricants are described. Good correlation is claimed between tests in automotive equipment and results obtained using the four ball and the S.A.E. tests. In spite of this, official policy in the U.S.A. is to rely only on full-scale tests using actual gears. Thus one test, the L.19, is run on the hypoid assembly of a passenger car, either on the road or on a chassis dynamometer. This is known as the "high speed-low torque test." Oils also have to pass the L.20 or "high torque-low speed" test, which is run in the hypoid rear axle of a 3/2-ton U.S. Army truck on a dynamometer test stand. The author does not discuss the possibility of substitution of the simple laboratory test, a more pressing problem for this country, where the destruction of a rear axle gear for each sample tested is almost prohibitively expensive.

Rheology, a term for the science of flow, but slowly gaining recognition by engineers in this country, is the title of the second chapter. The flow of lubricating greases provides an example of "non-Newtonian" behaviour, because viscosity of a grease cannot be expressed as a single number, but only as a function of the rate of shear. Methods for making this measurement are briefly described. As far as oils are concerned, additives which improve flow properties are now available. Thus the pour point of an oil, the lowest temperature at which it will flow under certain specified test conditions, is lowered by additives, e.g. poly alkyl naphthalene, which prevents the aggregation of the crystals of wax formed as the oil is cooled. This is probably achieved by the selective absorption of the additive on the surface of the crystals. The use of polymers such as polyisobutylene to reduce the change in viscosity with change of temperature is of considerable importance; one theory of their action is that the polymer exists either in true solution or in collodial suspension. The effect on increasing viscosity is most marked in the former state. Solubility, however, increases with temperature, so that the effect of the additive is more pronounced at the high temperatures partially compensating for the normally occurring fall in viscosity of liquids as temperature is increased.

Why does not an oil last for ever ? The main reason is oxidation, which leads to bearing corrosion, ring sticking and similar evidence of deterioration. The author devotes Chapter III to a detailed discussion of the chemistry of oxidation. Whilst a greater knowledge of chemistry is assumed in the chapter than is possessed by most mechanical engineers, detailed study is rewarding, as it goes to the heart of the question of the life of lubricating oils.

The tin-based white metals are very resistant to attack even by severely deteriorated lubricating oils, but newer bearing materials, such as copper lead and sintered bronze, are not so resistant. Bearing corrosion therefore has a whole chapter devoted to it. The author recognises three forms of bearing corrosion : "acid corrosion," "sulphur corrosion," and corrosion by aqueous acids. Additives again come to the rescue : first, preventing oxidation of the oil and consequent acid formation ; and secondly, inhibiting corrosion by, for example, laying down a protective film on the bearing surface.

Chapter V is devoted to lacquer deposition and sludge formation. The commonly accepted term of detergent is rather lightly tossed aside in favour of "dispersant" to describe the additives whose prime function is to keep oil-insoluble products of oil deterioration or combustion in the form of finely divided suspensions rather than as solid deposits which may prevent the piston rings from functioning.

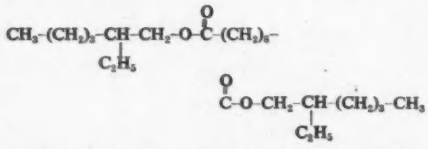
Engine oils are now assessed both in this country and in the United States using two engine tests. The L.1, which uses a single-cylinder Caterpillar engine to assess the propensities of an oil for preventing "ring sticking" and lacquer formation, and the L.4, which employs a four-cylinder Chevrolet gasoline engine to assess such factors as bearing corrosion and sludge and lacquer formation. Whether or not one considers that a test in one type of engine can be regarded as any indication of the performance of an oil in a different design of engine, there is no doubt that the service authorities in both countries regard these two engine tests as measuring those properties which are of importance in the performance of lubricating oils.

Emulsification and foaming are the subjects of the sixth chapter. Concentrations of silicones above 0·01 per cent are remarkably effective in preventing foam formation. The seventh chapter reviews the subject of "wear" somewhat sketchily, excepting that the adverse effect of sulphur in fuel on cylinder wear is emphasised. Such wear is corrosive and is accentuated at low temperature of operation (cylinder wall temperature below 60 deg. Cent.), when acids may be present in the liquid state. Alkaline additives consisting of organic salts of calcium or sodium have been claimed to reduce the rate of cylinder wear of an engine by over 50 per cent where the fuel contained 1 per cent sulphur. Unfortunately, the author gives no indication as to whether or not the present tendency towards increased sulphur content in diesel fuel is likely to persist.

The final chapter deals with the manufacture of lubricating oils and concludes by

* Bristow, J. R., Kinetic Boundary Friction, *Proc. Roy. Soc.* A. 189 pp. 88-102

referring to synthetic products. The aircraft gas turbine, for example, requires lubricants which, whilst withstanding high temperatures, are yet fluid at extremely low temperatures. Mineral oils, even with the maximum assistance afforded by additives, cannot meet these conditions and synthetic oils are required. A successful example is Di 2 ethyl hexyl sebacate :



The author has succeeded in compressing a remarkable amount of information into a compact volume and almost every statement is supported by references to original research. This, coupled with the author's position in the Wood River Laboratories, gives the book the character of an authentic work of reference which may become invaluable to all who have to understand what modern oil technology may do for engineering practice. Even those engineers, particularly builders of diesel engines for export, whose practice has not so far necessitated the use of oils containing additives, would be well advised to study the position. They may then be able to assure customers that ordinary oils suffice in their equipment because it is considered good economics to design for the appropriate condition rather than to employ the more exacting ratings permitted by modern but more expensive lubricants.

SHORT NOTICES

Concrete Roads. By F. N. Sparkes and A. F. Smith. London : Edward Arnold and Co., 41, Maddox Street, W.1. Price 80s.—The authors point out that the necessity of relating the design of a concrete surface to the nature of the soil supporting it is perhaps the most important of the changes of the last few years in the technique of constructing concrete roads. Therefore, some consideration is given in this volume to the properties and testing of soils, although this subject has been reduced to a minimum as it is dealt with in another of the volumes of the "Roadmakers' Library," of which "Concrete Roads" constitutes Volume 11. Other recent changes of which the authors have taken particular note concern mechanical methods of handling, placing and compacting concrete, and the appreciation of quality control. Some space has been devoted to theoretical aspects of the design of concrete slabs. Generally a comprehensive account of the subject is given, touching upon road layout, concrete mixes and properties, manual methods and plant, joints and drainage. There are two chapters on possible defects of concrete roads and one on maintenance.

Radioisotope Techniques, Vol. II, Industrial and Allied Research Applications. London : H.M. Stationery Office, Kingsway, W.C.2. Price 25s.—This paper-covered book contains a part—that devoted to industrial and allied research—of the proceedings of the Isotope Techniques Conference which was held in Oxford from July 16 to 20, 1951, under the auspices of the Atomic Energy Research Establishment. It may be recalled that the aim of the conference was to bring together the various users of radioisotopes, to promote discussion and establish liaison between workers in kindred subjects. There were thirty separate sessions, of which twenty were concerned with therapy and diagnosis, with biochemistry and with agricultural applications : this part of the proceedings is to be published later in Volume I. The remaining nine sessions dealt with industrial and allied research and the proceedings are recorded in Volume II, under review. At these sessions the papers were presented and discussed under the following headings—general applications, metallurgical applications, gamma radiography, counting techniques, chemical applications, ion exchange, non-destructive testing, static elimination and radioactive analysis.

Underpinning and Strengthening of Structures. By L. E. Hunter. London : Contractors Record, Ltd., Lennox House, Norfolk Street, Strand, W.C.2. Price 25s.—Underpinning is primarily a practical art, requiring experience to a greater extent than theory. Nevertheless, as with other practical arts, experience is more valuable and can be gained more profitably after study of the relevant literature, which, in the case of the subject covered by this volume, is not very extensive. The author's aim has been to keep the text within the scope of problems which occur in normal building practice. Full details of the calculations for the various cases discussed have not been given but the general method of design is indicated. No attempt has been made to include soil mechanics analysis. The various common methods of underpinning are described and the various classes of structures considered with relation to underpinning are normal buildings and bridge foundations. The strengthening of reinforced concrete structures, steel structures, masonry structures and bridge superstructures is described. There is a chapter on shoring and one on settlement and subsidence. The book breaks new ground in a chapter on foundations in subsoils subjected to heat, which, it is thought, will be of particular interest to engineers in the colliery and gas industries.

Major Faults on Power Systems. By A. G. Lyle, M.Sc. (Eng.), M.I.E.E., A.M.I.Mech.E. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 45s.—This book is the thirteenth volume in a series of monographs on electrical engineering, under the editorship of H. P. Young, M.I.E.E., M.I.A.E.E. It was written primarily to provide the practising engineer with a critical discussion of the behaviour of power systems under fault conditions, but it should also be of some use to university students in their final year. It deals with the behaviour of switchgear and protective equipment under fault conditions : although parts of the subject are treated in specialised books and papers, the whole subject is rarely found within a single volume. The emphasis of the text is on what happens to the system and the protective equipment, and on the values of current and voltage that accompany various kinds of fault. Although the author appreciates that few fault problems can in practice be analysed and solved in simple terms, he has nevertheless used simple cases to establish the principle. This knowledge should make it easier to understand the results obtained from the calculating machines that are necessary for solving practical fault problems. For the discussion of typical protective systems in relation to fault currents the author makes use of the theorem of symmetrical components and to illustrate the scope of voltage surges he introduces in the elements of Heaviside's operational calculus.

Rewinding and Repair of Electric Motors. By Karl Wilkinson. London : E. and F. N. Spon, Ltd., 22, Henrietta Street, W.C.2. Price 20s.—The purpose of this workshop handbook is to cover the usual run of repairs and rewinds to small motors : the methods, tools and equipment described are generally applicable to machines up to 50 h.p. A working knowledge of basic electrical theory is assumed and the book aims to show how to rewind an existing machine without modifying or redesigning it except to make minor changes in the voltage, for example. The author emphasises the need for craftsmanship, bearing in mind that, although many operations can be done by unskilled labour using machines, the bulk of the work in a small shop is done by hand. All the jigs and tools mentioned in the book can be made without exceeding the resources of a small shop equipped with a lathe, drills and press.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ENGINEERS AND STEEL CASTINGS

SIR,—In THE ENGINEER of March 6th your leading article on "Engineers and Steel Castings" is interesting and pertinent, but it omits one important factor, and it gives the impression that iron castings are impeccable ; an inference which will surely evoke dissent from users of general engineering castings !

You refer, sir, to the designer and to the founder, by which latter term it is assumed that you have in mind the foundry manager, metallurgist and other technical officers of the steel foundry, but no mention is made of the moulder who actually handles the sand and the molten metal.

When the writer was serving his pupilage in the early 1920s he and another pupil, not destined for foundry work, were the only young persons in the foundry, which was not a small one. The moulders were fine craftsmen but most of them were quite old, approaching retiring age, and there were no trained young men to take their places. Such a situation was not uncommon in foundries at that time, and it is suggested that this is one of the fundamental reasons for the present difficulties in obtaining even passably good castings in iron or steel.

The prevailing irresponsible attitude and lack of pride in their craft of so many foundry workers—with a few honourable exceptions—must also have a very detrimental effect on the quality of castings now produced, and it would be illuminating to know to what extent this is due to the lack of contact with true craftsmen and to the almost universal, and possibly inevitable, adoption of some form of piece-work.

Thirty years ago, in the foundry previously mentioned, and in others, it was almost a weekly occurrence—sometimes even more frequent—to cast hydraulic cylinders say, 15in in diameter by 20ft long, and larger, and it was a most unusual event for one to fail in the pressure test. To-day it is a most difficult matter even to persuade a foundry to submit a quotation for such a casting. Experience in various parts of England and Scotland has proved that the quality of castings, particularly iron castings and even in non-ferrous metals, has greatly deteriorated.

Strong exception is taken to the statement by Mr. Rowe that the designer lags behind the founder in the application of metallurgical and physical principles. In the drawing offices which are, and have been, under the control of the subscriber, it has been a long-standing rule that for all important castings and in cases of doubt, the foundry must be consulted before the relevant drawings are completed, and the offer is always made to consider any suggested modifications which will help the foundry. The response is often disappointing. Moreover, the useful booklets published by the B.S.F.A. are circulated in the drawing offices where they are much appreciated. In all this the subscriber claims that he is by no means unusual but is merely following a practice which is quite common amongst designers and users of steel castings.

E. C. HOUGHTON, B.Sc., A.C.G.I.
Wylam, Northumberland, March 11th.

DIMENSIONS ON DRAWINGS

SIR,—I was a little surprised to read the letter of Mr. George Asbury, in your issue of March 6th, on lack of uniformity in the dimensioning of drawings.

At evening classes, and later at the university, I was instructed that all dimensions up to 25in should appear in inches, and above that in feet and inches, subject to the condition that pipe diameters, shaft diameters, and length of stroke of engines, and the diameter of pump impellers

and rotating electrical gear should always be in inches.

This practice was followed in the drawing-offices in which I have worked, and it has been my practice to teach students to dimension drawings in this way. I was under the impression that it was a practice followed by all the larger drawing-offices.

There may be smaller and more recently established offices which do not conform, though it is recommended in B.S. 308 : 1943 (page 23) ; but, surely, further action is not required.

Nevertheless, whether or no any steps are taken to ensure conformity, I submit that the change-over at 24–25in is preferable on all counts to a change at 12in.

J. SYMONDS
Assistant Lecturer
Wandsworth Technical College, S.W.18.
March 15th.

SIR,—Regarding Mr. Asbury's suggestion in your issue of March 6, 1953, that draughtsmen should enter dimensions over 12in in terms of feet and inches, I would further suggest that they should refrain from entering, on the same print, a mixture of decimal and fractional dimensions, with an occasional touch of metric. I have seen all three on one print on several occasions. As inspection of engineering components is generally concerned with the usage of micrometers, verniers or similarly graduated instruments, it would suggest decimal dimensioning as the most logical British standard practice.

F. A. WALKER
Farnham Common, Bucks, March 10th.

BOOKS RECEIVED

Gesteinsbohren, Gesteinsbohrtechnik Druckluftwerkzeuge, Verdichter. Germany : Vulkan-Verlag Dr. W. Classen, Essen. Price Dmk. 12.60.

Theory of Elasticity and Plasticity. By H. M. Westergaard. London : Chapman and Hall, Ltd. 37, Essex Street, W.C.2. Price 40s.

Photometry. By John W. T. Walsh. Second edition. London : Constable and Co., Ltd., 10 and 12, Orange Street, W.C.2. Price 63s.

Railway Commercial Practice, Volume II : Freight. By H. F. Sanderson. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 30s.

Applied Heat for Engineers. Second edition. By J.-B. O. Sneeden. Glasgow : Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4 Price 20s.

African Press and Advertising Annual, 1952–53. Edited by Chas. R. Pask. South Africa : 616, Boston House, Strand Street, Cape Town. Price 25s.

Atmospheric Pollution. By A. R. Meetham. London : Pergamon Press, Ltd., 2, 3 and 5, Studio Place, Kinnerton Street, S.W.1. Price 35s.

Famous British Engineers. By Leslie Halward. London ; Phoenix House, Ltd., 38, William IV Street, Charing Cross, W.C.2. Price 12s. 6d.

Iron and Steel Works of the World. Edited by H. G. Cordero. London : Quin Press, Ltd., Birkett House, 27, Albemarle Street, W.1. Price 50s.

The Technique of Design. By P. J. Wallace. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 12s.

Getriebelehre 1, Geometrische Grundlagen. By P. Grodzinski. Germany : Walter de Gruyter and Co., Berlin 35, Genthiner Strasse 13. Price Dmk. 2.40.

Proceedings of the Eighth International Congress of Refrigeration. London : Institute of Refrigeration, Dalmeny House, Monument Street, E.C.3. Price 60s.

Aircraft Instrument Design. By W. H. Coulthard. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 40s.

Selection of Tables for Use in Calculations of Compressible Airflow. London : Oxford University Press, Amen House, Warwick Square, E.C.4. Price 40s.

The Science of Petroleum, Volume VI, Part I : The World's Oilfields—The Eastern Hemisphere. Edited by V. C. Illing. London : Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 52s. 6d.

A.S.T.M./I.P. Petroleum Measurement Tables, British Edition. Prepared jointly by the American Society for Testing Materials and the Institute of Petroleum. London : The Institute of Petroleum, 26, Portland Place, W.1. Price 50s.

The Design of Wheels for Electric Overhead Travelling Cranes

By H. B. LLOYD, B.Sc., A.M.I.Mech.E.*

The replacement of an old crane by a new one at the Workington Branch of the United Steel Companies, Ltd., offered an opportunity of observing the effect of change of design. The writer has been closely associated with certain proposals which have been made concerning the design of crane wheels, and the introduction of these proposals has resulted in an improvement which has surpassed expectations.

ELECTRIC overhead travelling cranes are widely used in industry and, in steelworks in particular, they are employed for continuous production duties which in many cases are very arduous. These cranes necessarily have a high span/wheel base ratio, so that the forces exerted by the wheel flanges, which ultimately keep the machine straight on its track, are far greater than, for example, in a locomotive or railway wagon. The maintenance of gauge on railway track is a simple matter compared with crane track, where spans of over 100ft are common and the gantries are frequently high.† It is thus not surprising that heavy flange wear occurs on the long travel wheels of many electric overhead travelling cranes.

Although there are very many cranes in service, they differ so widely as to span, load, duty, &c., that it is difficult to make direct comparisons on the effect of specific alterations in design. A recent American comment[1] summarises this with the remark "One of the most disturbing factors in this survey is the lack of factual data. In discussing crane wheels from Kansas City to the East Coast and from the Great Lakes to the deep South, factual data was practically nil."

CRANE DUTY

The crane concerned operates in the Bessemer department and its function is to off-load scrap from railway wagons, charge scrap and cold alloy additions to the Bessemer vessels and to charge hot additions of spiegel when manganese steels are being made. There are three other cranes on the gantry, but as they are special-purpose cranes this crane is also called upon for miscellaneous work. The time study of a typical working period, shown in Fig. 1, indicates the frequency of use of the various motions. Full lines indicate uninterrupted movement and dotted lines short movements necessary for positioning the crane. Short, sharp movements also occur on all motions when additions are being made to the vessel. The crane works seventeen production shifts per week and is employed on maintenance duties at the week-end.

The crab is fitted with both main and auxiliary hooks and the crane operates on a span of 57ft 10¾in. The gantry rails are 60ft above shop floor level.

COMPARISON OF OLD AND NEW CRANES

The leading particulars of the old and new cranes are shown in Fig. 2. The wheel base/span ratio has been increased from 1 : 5·79 to 1 : 4·28, and this tends, of course, to reduce the wheel flange wear. In order to enable certain additional duties to be undertaken the main hoist was increased from 10 tons to 15 tons capacity ; this makes the crane somewhat heavier and thus for the same operating speeds will tend to increase flange wear. The speed of the auxiliary hoist was increased from 35ft per minute to 40ft per minute in order to facilitate production.

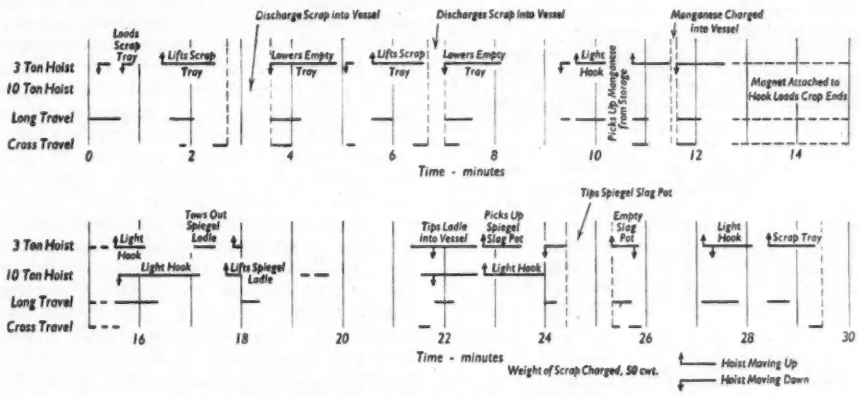


Fig. 1—Time Study of Working Period of a Steelworks Crane

The new crane was built by the Wellman Smith Owen Engineering Corporation, Ltd., and is of robust construction, suitable for steelwork's operation.

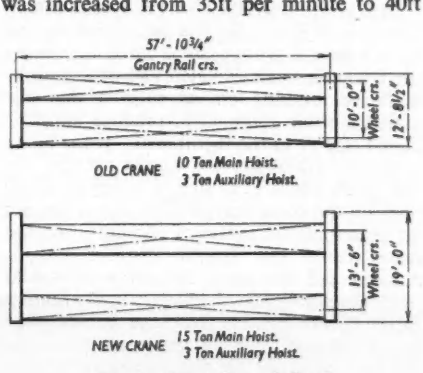


Fig. 2—Comparison of Cranes

WHEEL DIAMETER

During the preparation of the British Iron and Steel Research Association's specifi-

* Workington Iron and Steel Company. Technical Services Superintendent.

† "Crane Runway Maintenance," by H. R. Knust, and "Realigning Crane Runways," by M. F. Reece. *Iron and Steel Engineer,* Sept., 1952.

cation for heavy-duty electric overhead travelling cranes the writer was provided with information of the diameter, load, duty and operation of a large number of crane wheels in service, and two empirical formulæ, which are included in the specification, were devised to govern the selection of the diameter for long travel crane wheels. They are :—

$$D=\frac{W}{700a} \quad . \quad . \quad . \quad . \quad . \quad (a)$$

$$D=\frac{1}{11}\sqrt{\frac{WL}{a}} \quad . \quad . \quad . \quad (b)$$

where

D=wheel diameter in inches
W=wheel load in pounds
a=rail head width in inches
L=a duty factor with a value of 4 for medium-duty cranes and 6·5 for severe-duty cranes.

For any particular application the two values of D are to be worked out and the larger value, corrected upwards to the next quarter foot, is to be selected.

Formula (a), which is of a well-known form, is intended to make certain that the wheel is large enough to carry the load satisfactorily, whilst formula (b) is intended to make adequate provision for tread wear.

In the present case these formulæ yield values of (a) 22·4in diameter, (b) 29in diameter, so that the primary consideration

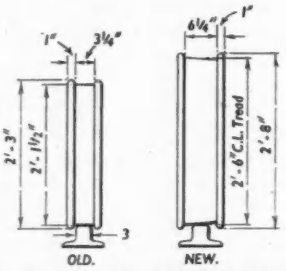


Fig. 3—Comparison of Crane Wheels

in the design of this particular wheel is that of wear, and a wheel diameter of 2ft 6in was selected. These formulæ will yield wheels somewhat larger than is common in American practice,[2] where the use of smaller wheels has been criticised.

Design of Tread

In a paper published by the Institution of Mechanical Engineers[3] the theoretical motion to be expected from a crane fitted with taper tread wheels was calculated and observations made on existing cranes showed that the actual motion obtained in practice approximated closely to the theoretical. If the crane is displaced laterally the wheels on one side bear on the rails at a slightly larger diameter than on the other side, so that the crane has an instantaneous centre of rotation. As the crane turns the lateral displacement is reduced and the crane follows a sinusoidal path, the amplitude of which is limited in the extreme case by the clearance between the rail head and the flanges. In the most common case of a four-wheeled crane with a pair of idling wheels and a pair of driven wheels linked by the long travel driving shaft it is shown that the sinusoidal motion is damped when the crane travels with driven wheels leading and is amplified when the idle wheels lead. As the wavelength of the motion is long this effect is not very serious.[4]

Based on considerations of the theoretical motion to be expected from a crane with tapered wheels, the writer has proposed that the distance between flanges should be considerably increased to allow the crane freedom of movement. He proposes that the tread width should be calculated by the formula

$$t=a+c+0{\cdot}035\sqrt{mDS} \text{ inches}$$

where

t=tread width, inches
a=rail head width, inches
c=a constant to allow for mal-alignment of track
D=wheel diameter in feet
S=crane span in feet
and the taper on the tread is 1in m.

In the case of the present crane c was taken as 1·5in and m as 16. This gives a value of 6·18in for t and the dimension used was 6¼in.

Details of the wheels fitted to the old and new cranes are shown in Fig. 3.

Stiffness of L.T. Driving Shaft

When contact occurs between a driving wheel flange and the rail the resistance to rotation increases, the stress in the long travel driving shaft increases and, according to its stiffness, the torsional twist increases. If the wheel on the other gantry remains clear of flange contact it will not be retarded, and consequently the crane will tend to rotate about the wheel which is restrained, and this rotation will increase the angle of impingement between rail and wheel. The stiffness of the long travel driving shaft thus has an important bearing on the tendency of the crane to skew. Another important consequence arising from an insufficiently stiff long travel driving shaft is that when one wheel turns relative to the other its end carriage advances and the crane structure as a whole is deformed. This places severe stress on the connections between the bridge girders and the end carriages. On many cranes these connections require frequent repair. An analysis of the stresses arising from this cause would be of interest, but is beyond the scope of this article. B.S.S. 466 does not stipulate a stiffness for this shaft, but the B.I.S.R.A. specification calls for 0·06 deg. per foot run at full-load torque. This figure is empirical. On the crane under discussion the stiffness was limited to 0·03 deg. per foot run. Torques of five times the full-load torque have been measured on electric overhead travelling crane long travel driving shafts.[5]

The old crane had a cross shaft of 3in diameter, as compared with 3¾in on the new crane. As stiffness is proportional to the fourth power of the diameter the new shaft has 2·44 times the stiffness of the old one ; the first motion gear reductions being about the same in each case and the drives being from similar motors, this increase in stiffness will result in proportionately less angular twist of the driving shaft.

Collector Gear

There are various systems for transferring the electric power from the gantry to the crane. In this case the down shop conductors are in the form of copper "T" bars, the horizontal part of the "T" being held in porcelain insulators, whilst the current is taken to the crane through a collector bearing upwards against the foot of the "T." In many designs of collector comparatively little allowance is made for relative movement between the collector and the conductor (except, of course, in the direction of travel). With wide taper tread wheels provision for considerable relative movement is essential and in the present case a trolley arm type of collector was fitted, contact with the conductor itself being through a rotating wheel mounted in the head of the arm and running on the foot of the "T." This arrangement has proved satisfactory.

Conclusions

On the old crane the rate of wear on the wheel flanges made it necessary to re-tyre the wheels after a month's service. It was customary to re-tyre one wheel each week-end. The new crane has now been in operation for a year and seven of the flanges show no appreciable wear ; indeed, they do not appear to have made contact with the rail. On the other flange there is no significant wear, but some material has been removed in such a manner that the profiles of rail and wheel are more alike. There is some wear on the wheel treads, but the amount is not of consequence.

There are no adverse effects to report concerning the rails ; these are, however, much heavier than would normally be used, as there is a 100-ton crane running on the same track.

Present knowledge does not enable a precise theory of flange wear to be propounded. There are many imponderables and it may well be that other (unknown) factors have assisted in the improvement brought about. Nevertheless, it is reasonable to assume that the design modifications described have played an important part in the remarkable improvement which has been effected. Arrangements are in hand for modifying a 100-ton crane running on the same gantry.

References

[1] "Crane Wheel Tread Contours," J. J. Stolz, *Iron and Steel Engineer*, October, 1952.
[2] *Loc. cit.*
[3] "The Effect of Tapered Treads on the Motion of Overhead Travelling Cranes," E. L. Diamond and A. M. Frankau, *Proc. I.Mech.E.*, 1950, Vol. 162, No. 3.
[4] Discussion on "The Effect of Tapered Treads on the Motion of Overhead Travelling Cranes," H. B. Lloyd, *Proc. I.Mech.E.*, 1950, Vol. 162, No. 3.
[5] "Preliminary Investigation into the Possibilities of Measuring the Torsional Stresses Set Up in the Long-Travel Driving Shafts of Electric Overhead Travelling Cranes," A. M. Frankau, British Iron and Steel Research Association Report No. PE/D/17/49 of July, 1949.

Improvements in Ship Performance*

The three main factors affecting the advance in ship performance are given as improvements in efficiency of main machinery, structural design and hydrodynamic design, and the paper is concerned with the last factor. Changes in ship proportions and higher speeds make it difficult to compare the resistance of ships as determined from models and the large area of laminar flow in the forebody of the earlier ships increases the difficulties. The two forms of viscous boundary flow are mentioned and it is emphasised that the surface friction coefficient is less for laminar than for turbulent flow and, since the pressure gradient of the forebody of ship models is favourable to laminar flow, while in the ship laminar flow is negligible, it is necessary to use artificial means to induce turbulent flow in the model.

Improvements in model resistance due to form changes means a reduction in residuary resistance and since the model factors remain constant a 5 per cent reduction in model resistance equals a 15 to 30 per cent fall in residuary resistance. The frictional resistance of a merchant ship is given as more than 50 per cent of the total resistance and the method of prediction of ship resistance from that obtained for the model is briefly outlined.

The resistance characteristics of several categories of ships are discussed, including the effect of the cruiser stern, raked stem, bilge radius, cutaway forefoot, and bow shape, embodying hollow and convex forms, and the bulbous bow. For deep sea merchant ships a

* Summary of Paper to the Institute of Marine Engineers, March 10th, by J. F. Allan, D.Sc.

graph shows lines of constant speed/length ratio plotted against ordinates of block coefficient and ©, and the liners indicate that a bulbous bow gives no benefit within the range of economic speed. For cross-channel ships a fine forebody is recommended, but the difficulties due to increased beam combined with restricted length are noted, together with the general adoption of the knuckled cruiser stern associated with hollow under-water sections.

With regard to coasters, it is stated that optimum forms result from employing a fine entrance and by locating the L.C.B. further aft, while the incorporation of the cruiser stern has greatly benefited resistance. The resistance performance to be expected to-day is illustrated by a graph in which curves of constant block coefficient associated with a propeller diameter are plotted on a base of speed/length ratio against the position of the L.C.B. relative to amidships and ©. For trawlers internal design has fitted in with the adoption of the cruiser stern and fine forward lines and some pointers are given regarding the methods to avoid high resistance. The question of roughness of hull is reviewed and the importance of this factor is underlined by the statement that resistance due to fouling may increase by as much as ½ per cent per day out of dock. On the question of structural roughness, flush-welded hulls are noted as giving a performance up to 20 per cent better than a riveted shell. Improvements in the design of rudders and stern frames are mentioned and suitable clearances between propeller, stern frame and rudder are suggested.

Propeller design improvements as effected by the changes in blade section shapes, which to-day are designed to avoid suction peaks, run parallel with the development of the vortex theory upon which detail design is increasingly based. It is noted that the higher speed of ships has increased propeller thrust and torque loading as well as the possibilities of vibration and cavitation; and photographs illustrate the effect of Karman-Trefftz sections upon tip vortex formation and back cavitation. Controllable pitch and shrouded propellers and the paddle-wheel are briefly mentioned.

To-day, it is stated, considerable attention is paid to the problem of hull vibration and efforts are made to avoid synchronisation between hull and other major exciting frequencies. The effect of the surrounding water, hull construction and of the superstructures is being examined and attention is drawn to the effect of increasing the number of propeller blades on the impulse frequency and the energy of each impulse. Factors affecting sea kindliness are reviewed and reference made to rolling, pitching, yawing and steering, and there is a particular reference to the activated fin method of roll stabilisation. The paper concludes with a summary of the improvements in performance, during the last twenty-five years, which amount to 25 per cent, including 5 per cent from the cruiser stern, 7 per cent from improved form, 8 per cent from improved stern frame and rudder and 5 per cent from improved propeller design; to the total may be added a further 15 to 20 per cent due to all welded construction.

Heating Metals in Suspension in an Electromagnetic Field

(By our American Correspondent)

In an effort to avoid the contamination incident to the heating and melting of reactive metals in a container, an interesting method of levitation or float melting has been developed by the Westinghouse Electric Corporation in America. The metal charge is suspended in a strong electromagnetic field generated by applying high-frequency alternating current to two coaxial coils connected in series opposition. The results obtained to date by means of this technique indicate that the melting, purifying, alloying and agitating of inert and reactive metals can be achieved without resort to crucibles.

IN melting the more reactive high-melting point metals such as titanium, zirconium, vanadium, tantalum, molybdenum and others of similar chemical and physical characteristics, difficulty is usually encountered due to reaction with crucible materials, and other reactions may occur which adversely affect the quality of the melt. Thus, titanium, when melted in a graphite crucible, is likely to contain several tenths to one or more per cent of carbon. When zirconium is melted in contact with oxide-containing crucibles, it becomes embrittled because of absorption of oxygen from the refractory. If the crucible is sufficiently cooled, in an effort to reduce contamination of the melt, other unsatisfactory results may appear. Again, when metals are melted in a crucible of water-cooled copper, as in the arc melting process, the resulting ingot has a very rough surface and often possesses holes or voids. In view of these difficulties, the Lamp Division of the Westinghouse Electric Corporation at Bloomfield, New Jersey, in co-operation with the central research laboratories of the company at East Pittsburgh, Pennsylvania, has conducted a research programme aiming at the development of a melting technique which would reduce or prevent contamination, and provide continuous agitation of a melt. In an attempt to realise this objective, several plausible methods were considered :— Magnetostatic levitation with simultaneous induction melting ; electromagnetic or induction levitation with simultaneous induction melting, and acoustic levitation with simultaneous acoustic or induction melting. Of these methods the second appeared most promising and therefore was investigated.

Initial experiments, in air, involved a single coil. Although a brass specimen was supported by the alternating magnetic field established by the energised coil, it drifted laterally from the coil axis and fell out of the influence of the field. The force acting to maintain the specimen at the axis and above the coil was, therefore, found to be inadequate. With more power the levitated specimen rotated, melted, and thereupon uncontrollably flowed down out of the influence of the coil field. The experiment was repeated with other metals with the same undesired results. However, initial experiments with brass, tin, aluminium and titanium specimens weighing up to 550 grammes indicated that in the solid state, at least, vertical support by the alternating magnetic field could be provided with the available alternator. It remained to investigate the magnetic field distribution required for the stable levitation of molten as well as solid metals, including the controlled draining of the melt. By a combination of theoretical considerations and experimental work it was discovered that one way in which an adequate radial restoring force could be realised was by two coaxial coils, as illustrated in principle by Fig. 3. They are

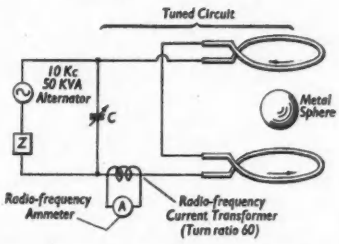


Fig. 3—Circuit Diagram of Coaxial Coil System

connected in series across a common capacitor *C* so as to constitute a parallel tuned load to the alternator. The alternating currents in the coils, which are generally unequal, are in series opposition at all times. The currents in these fixed coils induce in the interposed metal charge, which may be a sphere, as in Fig. 3, eddy currents whose interaction with the inducing field gives rise to the necessary supporting and lateral restoring forces. These make possible the stable levitation of solid metal specimens, and are the principal factors in the levitation of the subsequently molten metal. The heating and melting of the levitated specimen depends upon the power available, the coupling between the primary

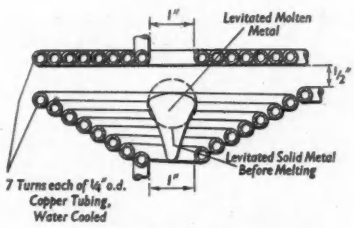


Fig. 4—Details of Coaxial Coil System

circuit and the specimen, the frequency, the eddy current and hysteresis losses in the specimen, and heat losses from the specimen.

The initial investigation conducted at the Bloomfield Works proceeded to the point where it was possible to insert from above or below the coil system slugs of any shape of various conductive materials into the " interaction space " between the coils, as illustrated by Fig. 4, for a particular coil system. Conductive materials, such as brass, aluminium, tin, compacted titanium powder and molybdenum were used in the experiments. The solid specimen was

Fig. 1—Levitation of Solid Aluminium Sphere

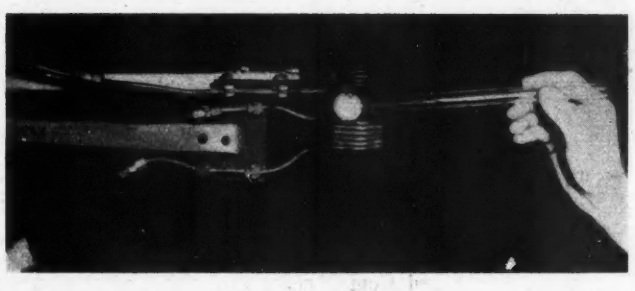


Fig. 2—Displaced Aluminium Sphere Returning to Equilibrium Position

levitated by adjustment of the alternating current in the coils. The levitated specimen began to heat, and the rate of its temperature rise could be controlled by varying the magnitude of the alternating current, controlled at any rate above the level corresponding to the minimum current that would support the specimen. In those cases in which the specimen continued to be supported while molten, it assumed the shape of a top and remained stably levitated, but at a somewhat lower position in the field, as illustrated in Fig. 4. Sometimes aluminium already in the molten state was introduced into the interaction space ; it immediately assumed the form illustrated. In the levitated state the molten mass was vigorously agitated by the interacting alternating magnetic fields. The specimen tended to rotate about the axis of symmetry, but this rotation was generally slow and could be prevented by introducing axial asymmetry. Finally, the molten levitated mass could then be drained into a suitable receptacle, or dropped as a whole by merely adjusting the current in the coils. It may ultimately even prove possible to resolidify the levitated molten metal and then drop the solid into a suitable receptacle.

In an effort to obtain preliminary design data so as to provide more effective and stable levitation of the molten metal, many designs of coil systems were investigated. Preliminary electrodynamic tests were also conducted with various coil configurations to determine their effectiveness in the heating and levitation of metals. The levitated specimens were loaded by weights, and thermocouples were inserted to register average temperatures. Although this attack was susceptible to some defects, useful design data were obtained with the aid of electrolytic tank plots of the fields of a variety of coil designs.

When molten metals, such as aluminium, were levitated in air, it was evident that they soon became coated with oxides or other compounds. A question arose as to the importance of this oxide coat in making the molten metal levitation possible. On the one hand, it seemed that it could not be of much account, for the vigorous agitation of the molten metal cracked whatever film was formed so that islands of film swam on the surface. On the other hand, the stability of a melt obtained with coils as shown in Fig. 4 might depend on preventing pour from starting at the bottom. A film of oxide there might possess an efficacy out of proportion to the area it covered. Since the chief applications of the method would eventually be in a vacuum or a protective atmosphere where little or no film would form, the later vacuum and atmosphere experiments to be described below were, therefore, of major interest.

Fig. 1 shows the levitation of an aluminium sphere in the interaction space by the induction fields of two coils connected in series opposition. Appreciable restoring forces were experienced when the sphere was pushed in various directions from its equilibrium position in the interaction space. In each case the sphere returned to its equilibrium position near the centre of the coil system, as illustrated by Fig. 2. The aluminium specimen was allowed to start melting in air while being levitated by the alternating magnetic field of the coils. As it did so, it assumed the shape of a top as illustrated by Fig. 5. Sometimes, as melting of the levitated specimen progressed, portions thereof flowed downward and intermittently dropped out of the field. It has been found that in order to avoid this tendency to drain, the size and mass of the levitated metal may be decreased, the circulating current in the coils may be increased, or the coils may be more effectively shaped in order to levitate both the molten and solid metal. A decrease of the circulating current in the coils leads to draining of the molten metal in a thin column from the levitated top, as shown in Fig. 6.

Experiments have indicated that for most effective levitation and induction heating of a metal specimen, an optimum coil configuration exists and that it varies with the type of specimen and depends on whether it is in the molten or solid state. Although data have been obtained regarding the levitation characteristics of various coil configurations, the aspect of the work is not yet sufficiently established for general application. However, it is appropriate to cite a typical experiment. The example involves a double coil system as illustrated by Fig. 4, the coils being connected in series opposition. Stable levitation was observed with solid and molten aluminium (21·5 grammes), solid molybdenum (154 grammes), and solid copper (80 grammes). Both of the latter elements were at red heat. The coil currents amounted to 630A, 720A and 630A respectively, and the frequency was 10,000 c/s. No attempt was made to melt the molybdenum and copper specimens. A ½in diameter, 1in long aluminium rod was fed into the molten metal from above the coil system without disturbing the stability of the levitated molten aluminium. This result indicates the feasibility of replenishing the melt.

In the course of the work conducted at the East Pittsburgh laboratories, various masses of aluminium, silver and aluminium bronze were levitated stably in air, in the solid state just as had been done at Bloomfield. In the molten state, aluminium was levitated with ease. Molten silver was levitated between coaxial coils on one occasion, but was found to drift laterally out of the field. On other occasions, when melting commenced, the molten silver drained downward and dripped away from the lower surface of the remaining solid metal, apparently without much interference from the alternating magnetic field which was concurrently supporting the solid metal. It was observed that silver melts in air without forming a protective oxide film like aluminium.

The vacuum trials at East Pittsburgh were made under a bell jar of 9½in inside diameter and 18in inside height, which was mounted upon a vacuum system consisting of a few feet of 8in Monel pipe. The system was evacuated by a Westinghouse 8in oil diffusion pump backed by a Distillation Products 8in "MB-300" booster pump and a Kinney "CVD8610" mechanical pump. The pressures during the levitation runs were in the range of 10^{-4}mm to 10^{-5}mm of Hg. as measured by a cold-cathode discharge vacuum gauge.

The metal to be levitated was at first laid in an alumina cone that nested into the lower coil. Later, the charge was initially supported on a water-cooled pedestal of either non-magnetic or magnetic metal. It was hoped that the pedestal, which reached up into the lowest turn of the lower coil, might alter the electromagnetic field in a manner favourable to preventing pour from the tip of a levitated melt. *In vacuo*, as in air, it was possible to levitate and heat various metals, such as aluminium, silver and titanium, in the solid state. On melting, however, the aluminium usually dripped downward, even in a coil and with a current that would have supported the liquid if surrounded by air instead of vacuum. Eventually, it was found possible to levitate approximately 10 grammes of molten aluminium in vacuum for about one minute. But even then it became apparent that there was still a film which segregated as wrinkles at preferred sites on the molten surface in about one minute. In one particular experiment, an aluminium ball 1in in diameter was floated by means of currents of 600A to 800A. It split in half, but one-half continued to float, melted, then floated molten for about a minute in the shape of a thin pear with its point down. The surface appeared very bright and clean at first, but toward the end traces of film were seen. The gauge indicated a vacuum of 10^{-5}mm Hg. throughout the test.

A lump of titanium was almost completely melted while in levitation. Silver, however, always began to drain as soon as it melted. At the same time, opaque films began to form on the inside surface of the bell jar which enclosed the vacuum, so that observation of melted silver could never be carried on for a long period.

In another approach to the problem, a pair of parallel conductors were employed instead of coils. The conductors were 6in lengths of ¾in O.D. copper tubing, mounted at a centre distance of 1in. The currents employed reached a maximum of about 2000A. Bars of aluminium, zirconium and copper about ½in in diameter and 4in long, were readily levitated in the solid state between the conductors. In a hydrogen atmosphere a copper bar was levitated partially molten. However, the support of completely molten metal was not achieved by this arrangement.

Although the experiments described have dealt with masses of the order of a few hundred grammes, and circulating currents of the order of 700A at about 10,000 c/s, these magnitudes do not necessarily represent limiting or optimum values. The mass to be levitated has been found to govern, at a given frequency and coupling, the magnitude of the circulating current required, the availability of which is in turn dependent in part upon the efficiency of the coil system and the tuned circuit as a whole. Both the levitation force and the induction heating power input vary as the square of the circulating current in the coil system. Hence it is obvious that the resistance of the coil system should be a minimum. It has been shown that the frequency and the equivalent Q of the levitated mass should be such that the skin effect is appreciable. On this basis it has been estimated that metallic masses up to several pounds may be stably levitated with a 50kVA, 10,000 c/s alternator.

A limitation of the existing coil systems is the relatively low electrical heating efficiency of induction coils surrounding a relatively small charge. As a result of the work completed so far, it cannot be said that the feasibility of levitating molten metal in a protective atmosphere or *in vacuo* has been firmly established. It seems certain that oxide coats which form in air make flat melting easier, but whether such coats are essential, at least for charges beyond a certain size, remains to be investigated further.

The experimental work reviewed in this article was conducted by E. C. Okress and D. M. Wroughton, of the lamp division, and G. Comenetz, P. H. Brace and J. C. R. Kelly, of the central research laboratories, Westinghouse Electric Corporation.

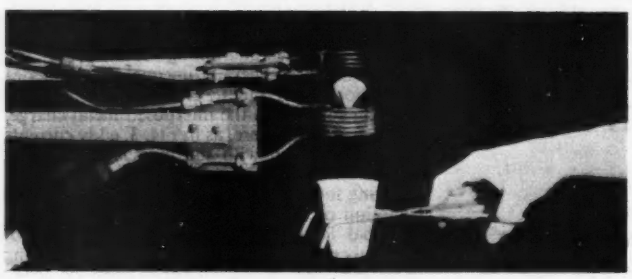


Fig. 5—Aluminium Sphere Starting to Melt

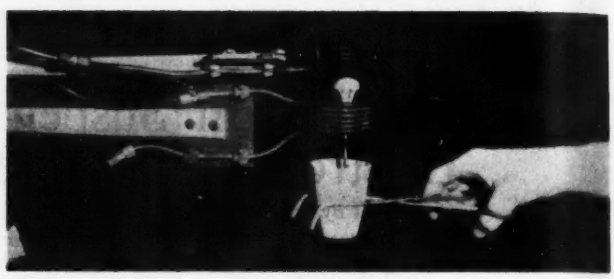
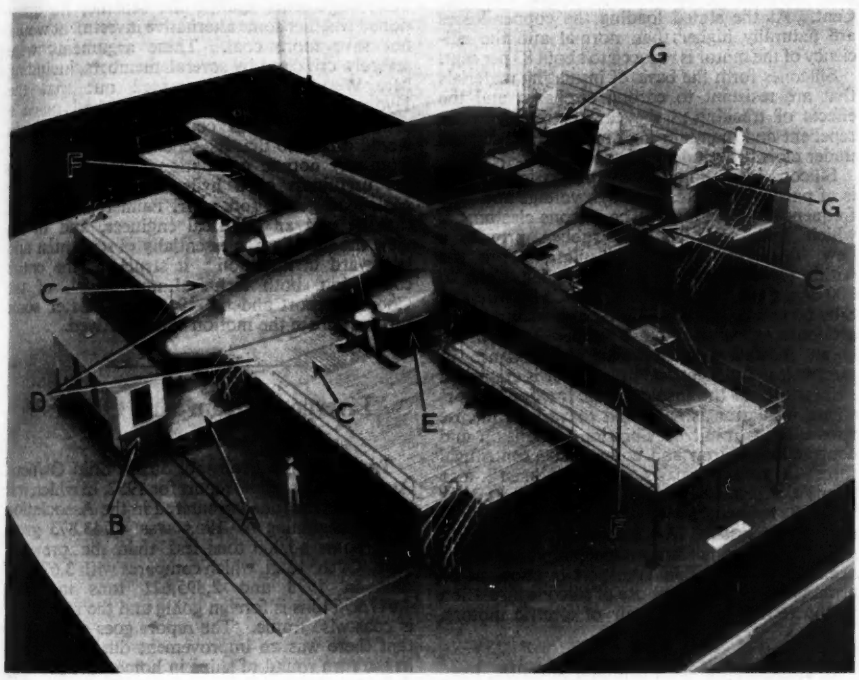


Fig. 6—Draining of Molten Aluminium

British European Airways Docking Facilities

THE first steps in producing a complete maintenance dock in this country were taken in 1947, when British European Airways Corporation appointed Messrs. Wilson and Rodger as their consultants for maintenance docks, and initiated the design of the first complete dock. This was to be for the Corporation's "Dakota" aircraft.

It was felt that, as the "Dakota" was to be replaced by more modern aircraft in the course of the next few years, a permanent dock would not be justified, but that one which would serve as a prototype for subsequent permanent docks should be designed so that as much material as possible should be recoverable. The "Dakota" dock was erected in the British European Airways Corporation's hangars at Renfrew Airport in the autumn of 1949. It was, in effect, a double dock, handling two aircraft, nose to nose, simultaneously, was constructed of scaffold tube connected by "Kee-Klamps" and standard scaffold connections, and carried a timber deck. Various sliding or folding stairways and plinths were provided to give access to all vital parts of the aircraft.



Model of Dock for "Elizabethan" Aircraft

An investigation has now shown that the cost of carrying out a No. 4 check has been very considerably reduced and the time of turn-round has been much improved. These considerable economies encouraged the British European Airways Corporation to initiate projects for full-scale permanent docks for No. 4 checks on Airspeed "Ambassador" or "Elizabethan" class aircraft and the turbo-propeller Vickers "Viscount" or "Discovery" class aircraft.

The illustration shows the "Elizabethan" dock which is now being fabricated by the Heston Aircraft Company and installed by it in the new B.E.A. hangars at London Airport. The "Discovery" dock, which it is also intended to install at London Airport, is still in the design stage. Both are full-scale docks embracing the whole aircraft, and are of a semi-permanent form of construction. As it was anticipated that both docks may well be in service for ten years or more, during which time it is improbable that the necessity to effect major modifications will arise, it was not considered desirable to adopt one of the patent forms of construction which might provide ease of alteration at an increased cost and at the expense of rigidity.

The "Elizabethan" dock is mainly constructed of rolled steel channel beams which are supported by tubular columns and carry a hardwood deck. The aircraft will enter the dock tail first, thereby permitting the positive fixing of the entire dock structure with the exception of the small 1ft 6in high nose platform *A*, which is mounted on flanged wheels running in rails set flush with the hangar floor, as is a mobile office *B*. Hinged flaps *C* are provided in the deck where, although a floor is usually required, it is sometimes necessary to have a gap—for example, in the tail structure to give unobstructed passage to the lower portion of the fins and rudders or in the front platforms to give passage to the main undercarriage, or along the inner edges of the side fuselage platforms in order to produce a close fit along the sides of the aircraft once it is in position *D*. Four hydraulically operated platforms *E*, are provided one at each side of both engines, to give easy access to any part of the power plant. These are so actuated that the level of any platform can be independently adjusted by the operator working upon it by means of a hand-high control valve mounted on the moving platform. At the trailing edge of each wing a light alloy staircase gives access to the upper wing surface. These staircases, when not in use, fold down below the deck level, leaving an unobstructed walkway. They carry a reel of canvas backed pipped rubber matting which, to protect the skin, can be pulled over the wing from trailing edge to leading edge, where automatic folding ladders (retracted in the illustration) can be erected between platform level and the upper wing surface. The permanent platform levels have been carefully determined in an effort to ensure that an operator of average height can comfortably reach all parts of the aircraft, pits *F* being provided under each wing and under the tailplane, and hinging cantilevered platforms *G* being fitted at the tail. These platforms, when down, give access to the upper hinge points of the rudder, and when up leave a clear space above the tailplane to facilitate its removal.

During a No. 4 check the aircraft will always be jacked up to permit undercarriage retraction tests and inspections to be done, therefore main wing jacks are built into the dock, as are nose wheel jacks, wing steadies and a tail trestle, and the main platform levels have been arranged so that they are at the correct height around the aircraft when it is upon the jacks.

High-pressure grease is carried in fixed pipes under the decking, and is fed up through it in high-pressure flexible grease hose which is wound on an automatic coiling device and which terminates in a grease gun. To service any nipple, the fitter need only reach for the nearest gun and pull out the hose attached before applying the gun to the nipple. The hose is retracted beneath the deck, thus avoiding a tangle of piping on a walking platform. By limiting the lengths of the flexible hose the gun remains close to the nipple for which it is required, and cannot be taken away or mislaid. Electricity at 250V and 440V is supplied where required for lighting, for power, soldering irons and for inspection lamps. Air is supplied for working hand tools and for operating suction cleaners. Water is supplied for recharging the aircraft tanks in the galley and the toilets, and the provision of a drainage system allows the flushing out of the tanks. Dry air is provided for clearing instrument pressure static systems, and an oil drainage scheme ensures that the hangar floor will be free from spilt and dirty oil when engines are drained and filters cleaned. A hydraulic test rig is installed, so that hydraulically operated components may be tested while the aircraft is docked.

The dock now being designed for the "Discovery" differs only in detail from the "Elizabethan" dock. The "Discovery" fuselage is higher and it is necessary to provide a third working level along the sides of the fuselage. This third level being higher than the tailplane is arranged to be retractable. This has been achieved by mounting the entire high-level platform on latticed columns, the bases of which are carried on bogies whose wheels run in channel guides which are fixed to the low-level side fuselage platform. Each bogie also carries a nut which engages with a lead screw. The lead screw is rotated by reversible air motor through bevel gears, universal couplings and shafts. This arrangement enables the high-level platform, which cantilevers 26ft, forward over the wing to be completely under control during the retraction and extension operation.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

FLAT DIES FOR THREAD ROLLING

No. 1946 : 1953. Price 4s. This specification presents dimensional and accuracy requirements for flat thread rolling dies, intended for the production of Unified, Whitworth and B.A. threads. Two separate methods of production of the dies have been devised, one finishing the form by grinding, the other by milling, and the limits of tolerance on the thread forms in the specification refer to the former only. The accuracies pertaining to the various die faces and planes have been extended to the duplex form which has been widely adopted.

An appendix gives some useful hints on thread rolling for those seeking information on this production process.

CIRCULAR DIES FOR THREAD ROLLING

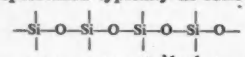
No. 1947 : 1953. Price 4s. This standard relates to the circular thread rolling die developed along parallel lines to the flat dies, of which specification requirements are set forth in the complementary publication, B.S. 1946. The thread form tolerances relate to Unified, Whitworth and B.A. threads and are intended for the production of threads to the close fit limits of the various systems, although an allowance for die wear is also included. Although not forming part of the actual specification, the information and production hints presented in the appendix will be found very useful in view of the sparseness of published data on thread rolling. The publication makes no claim to be an exhaustive survey of the process, but will certainly assist those concerned with its problems.

Silicones for the Electrical Industry

AN exhibition of silicones for the electrical industry is being held this week from March 17th until to-morrow, Saturday, March 21st, at 19, Upper Brook Street, London, W.1, the headquarters of Midland Silicones, Ltd. The exhibition has been organised by this company with the co-operation of a number of firms which manufacture insulating materials containing silicones.

The developments shown in this exhibition originated in 1943, when the Dow Corning Corporation of America was formed to manufacture and supply silicones. To meet the need for these materials by British industry Albright and Wilson, Ltd., undertook the importing of the Dow Corning products in 1947, but initially supplies were limited to defence requirements. In 1950 Midland Silicones, Ltd., was formed, in association with Albright and Wilson, Ltd., and began to supply Dow Corning silicones on an increasing scale. More recently a manufacturing plant has been built in Great Britain, where silicone production has already begun. By the middle of this year a variety of British made silicones is expected to be available and, in due course, to make this country independent of American supplies.

Only a very brief reference to silicones and their properties need be made here. Essentially, silicones are synthetic chemical products based on a chain of silicon and oxygen atoms, which may be represented typically as follows :—



Organic groups are attached to the silicon atoms. By varying the basic silicone structure and of the attached organic groups, a great number of different products can be made, including fluids, resins, elastomers, greases, water-repellent products and other materials for use in diverse industries.

In spite of these variations in composition and form, all silicones exhibit certain common properties, chiefly their stability to heat, cold and oxidation. Many of the resins, rubbers and fluids can be used at 250 deg. Cent. (482 deg. Fah.), while, for application at the lower extreme, are other fluids with freezing points of −86 deg. Cent. (−120 deg. Fah.) and rubbers with brittle points below −90 deg. Cent. (−130 deg. Fah.). Silicone paints have very good weathering properties which can be attributed largely to their resistance to oxidation. Films of silicones are water-repellent and water will condense as discrete drops on surfaces treated with them. It may be stated, in passing, that this property is put to use in the treatment of textiles to develop shower-proofness, for coating glass and ceramics to improve their surface resistivity in humid conditions, for water-proofing leather, treating masonry and for making the inside of drug phials water-repellent so that none of the contents remain behind when they are emptied.

The specific purpose of this exhibition, however, is to draw attention to the electrical properties of silicones. The silicone resins and elastomers combined with mica, glass-cloth and asbestos result in a new class of insulation that will withstand operating temperatures at least 50 deg. Cent. above class "B" insulation limits. As a result of this development the American I.E.E. provisionally introduced a new insulation rating known as class "H" that permits continuous operation of electrical machinery at a hot-spot temperature of 180 deg. Cent. Laboratory tests and field experience in America and this country have shown that silicone insulated equipment will give long service at 200 deg. Cent. and will withstand intermittent exposure to temperatures as high as 300 deg. Cent. An international class "H" insulation rating is now under consideration.

To illustrate these properties as applied to the insulation of electric motors the exhibition contains a demonstration of a G.E.C. squirrel-cage motor using silicone bond insulation and impregnants throughout. Full details of tests on such a motor are given in a paper, "Silicone Resins, Fluids and Elastomers in Insulation for Use at Power Frequencies," presented by W. J. Renwick and J. R. Reed, at a Symposium of papers on insulating materials, organised by the Institution of Electrical Engineers in London earlier this week (see page 421).

For the slot liners of this motor two pieces of glass-backed mica, each 10 mils thick, were used with the mica faces contiguous, impregnating varnish DC996 being used for bonding. The round copper wire conductors were insulated with a double covering of glass fibres varnished, as above, with DC996; the wires were 22½ S.W.G. with a 6·5 mils diametral thickness of covering. For taping the overhang use was made of a commercial 4 mil by ¾in silicone-varnished woven glass tape. The slot wedges were machined from silicone bonded asbestos boards and the terminal boards were machined from silicone-bonded glass fabric boards. Two ball bearings, lubricated with silicone grease MS44, were used in standard endshields.

In the exhibition the motor, which is protected enclosed in a 1 h.p. standard frame size, is shown developing 3½ h.p. continuously when driving a generator to provide the required loading. Under these conditions the slot temperature, measured by thermocouple, is 260 deg. Cent. and the bearing temperature about 130 deg. Cent. At the stated loading the copper losses are naturally higher than normal and the efficiency of the motor is reduced to about 83 per cent.

Silicones form the basis of insulating materials that are resistant to corona discharge and the effects of tracking; they are extremely water repellent and maintain high insulation resistance under moisture-condensing conditions.

Silicone insulation has low dielectric loss that is of particular interest for high voltage and high frequency applications. The silicone elastomers, which look and feel like rubber, provide a new form of electrical insulation for use within the temperature range −50 deg. Cent. to 200 deg. Cent. "Silastomer," made by Midland Silicones, Ltd., remains elastic and maintains its dielectric strength at these temperatures, which is an indication of its extreme resistance to mechanical and electrical fatigue. It is employed successfully in the insulation of traction motors where insulation is subjected to various intense stresses as a result of vibration, expansion and contraction of iron and copper, and centrifugal force in rotating parts. "Silastomer" also forms the primary insulation on cables for use in high temperatures and on important communication systems where circuits must continue to function through fire. One exhibit shows the armature of a London Transport traction motor arranged to illustrate the use of silicone insulation in the rewinding and repair of electric motors.

Exhibitors

In collaboration with Midland Silicones, Ltd., the following firms are exhibiting the products indicated.

Ashdowns, Ltd., Eccleston Works, St. Helens, Lancs: "Ashlam" silicone-bonded glasscloth laminates, plate, tubes and fabricated parts; Bakelite, Ltd., 12-18, Grosvenor Gardens, London, S.W.1: silicone-glass-laminated sheet, silicone moulding compound; British Insulated Callender's Cables, Ltd., 21, Bloomsbury Street, London, W.C.1: silicone-insulated cable, coil end flexibles, winding wire and sleeving; The Dunlop Rubber Company, Ltd., Cambridge Street, Manchester: silicone elastomer products including electrical insulating tapes, press-cured and calendered sheets, coated fabrics, moulded parts; Fibreglass, Ltd., Ravenhead, St. Helens, Lancs: Fibreglass "E-glass" yarn cords and tapes; Glass Fabrics, Ltd., 213, West Campbell Street, Glasgow, C.2: pure glass yarn and fabrics; Ioco, Ltd., Anniesland, Glasgow, W.3: "Silopex" silicone-varnished glass-cloth and tapes; Jones, Stroud and Co., Ltd., Highfield Mills, Long Eaton, Nottingham: "Vidaflex" silicone-saturated glass sleeving, silicone-treated glass tying cord; The Liverpool Electric Cable Company, Ltd., 24, Queen Anne's Gate, Westminster, London, S.W.1: silicone-insulated cable and wires; London Electric Wire Company and Smiths, Ltd., Church Road, Leyton, London, E.10: silicone-bonded glass-braided cable and strip, glass-lapped strip and round wires, silicone-varnished glass-cloth and tape; The Micanite and Insulators Company, Ltd., Empire Works, Blackhorse Lane, Walthamstow, E.17: silicone-varnished glass-cloth and tapes, silicone-bonded flexible mica, mica/glass, and glass/mica/glass combinations, silicone-bonded glass-cloth laminates, hard micanite; Peerless Mica Company (Aust.), Pty., Ltd., Abbey Barn Road, Wycombe Marsh, High Wycombe, Bucks: silicone-bonded flexible mica plate and tapes; Plywood Industries, Ltd., 18-30, Leonard Street, London, E.C.2: silicone-bonded asbestos board; Rist's Wires and Cables, Ltd., Lower Milehouse Lane, Newcastle under Lyme, Staffs: silicone-insulated flexibles and cables; F. D. Sims, Ramsbottom, Lancs: silicone-bonded glass-covered wire and strip; H. D. Symons and Co., Ltd., Park Works, Kingston Hill, Surrey: silicone-elastomer coated glass-cloth, sleevings, silicone-bonded mica/glass-cloth.

The Breadalbane Hydro-Electric Scheme

ON Wednesday, March 11th, there was some discussion in the House of Commons about the Breadalbane hydro-electric scheme. Colonel A. Gomme Duncan moved that the confirmation order for the scheme be annulled. His motion was seconded by Mr. Nabarro. Put very briefly, one of the main points made against the scheme was that with severe restrictions on capital expenditure, a certain measure of criticism could be made against its cost. However, the scheme's desirability in general, from both the technical point of view and from the point of view of its effect on the amenities of the district, were discussed at some length. It was pointed out by Colonel Gomme Duncan that the estimated expenditure was at first £15,500,000, which had since been amended to £18,500,000. Mr. Nabarro recalled that the estimate for the Loch Sloy scheme was £4·6 million, and the cost to date had been £9·25 million. He added that the cost per kilowatt installed of the Breadalbane project was £204, compared with £68 for a steam station, but the amortisation was about equal in each case, owing to the longer life of the water power scheme. He then pointed out that the load factor would be 40 per cent for the Breadalbane scheme, as against 80 per cent at the Portobello power station of the B.E.A., so that, he argued, the capital cost at Breadalbane was six times as great as at a modern steam plant. Presenting other arguments against the scheme, he questioned whether some alternative investment would not save more coal. These arguments were severely criticised by several members, including Mr. Woodburn, who pointed out that the Hydro-Electric Board up to now had made a profit and as far as could be judged, always would do so, so that its schemes were economic from any normal calculations. He emphasised the usefulness of a hydro-electric scheme for peak load generation. Mr. Palmer pointed out that he was an electrical engineer, and in his view the motion was essentially obscurantist and backward in intention; it struck at the entire conception, both technical and social, of the Cooper Report and the 1943 Act. After some further debate the motion was negatived.

Liverpool Steam Ship Owners' Association

THIS week the Liverpool Steam Ship Owners' Association issued its report for 1952, in which it is stated that the tonnage entered in the Association at the beginning of 1953 was 4,743,873 gross tons, some 50,000 tons less than the previous year. Of the total, which compares with 3,678,907 tons in 1938 and 2,895,621 tons in 1945, 4,647,996 tons is foreign going and the remainder is coastwise traffic. The report goes on to state that there was an improvement during the year in the turn round of ships in home ports, mainly due to contraction in imports, which resulted in a reduction in volume of cargo discharged and less congestion on the quays. Turn round conditions at terminal ports abroad varied and the report gives details of the position in several trades and a number of countries, and remarks upon the superiority of ports in the United States and the Continent, quoting, as an example, the bulk grain discharge rate at Hamburg as 100 tons per hour, against about 78 tons per hour in London. Import cuts helped to improve conditions in Australian ports, but it is remarked that there continues to be industrial stoppages on the slightest pretext. With reference to the short sea trades, the value of the three-shift system at Antwerp is noted and it is stated that the main problem is to lower British freight rates to a competitive level. Lack of details of weight of exports in the official returns hampered the overseas trade survey, and the report comments that figures giving the value of trade are useless for comparative purposes due to price fluctuation and changes in monetary values. The report gives details of the weight of imports, tonnage employed and the value of the principal exports, and estimates that the trade deficit for 1952 will be approximately £520 million, compared with £940 million in 1951.

Steam Turbine Research and Development

THE INSTITUTION OF MECHANICAL ENGINEERS

No. II—(*Concluded from page* 394, *March* 13*th*)

AT the second session of the conference on steam turbine research and development, on Friday, March 6th, the following papers were presented :—

SOME REFLECTIONS ON THE THERMAL DISTORTION OF TURBINE CASINGS
By BASIL J. TERRELL, M.B.E., B.Sc. (Eng.)

THE DETERMINATION OF NATURAL RESONANCES IN MECHANICAL SYSTEMS
By Dr. O. P. T. KANTOROWICZ

THE APPLICATION OF RESEARCH TO MARINE TURBINE DEVELOPMENT
By T. W. F. BROWN, D.Sc., S.M., M.I.Mech.E.

Mr. P. J. Pollock said that Mr. Terrell had taken the temperature gradient across the cylinder wall as being the major cause of distortion. But a temperature gradient in the axial direction could also produce severe plastic strain, especially where the diameter varied appreciably along the axis. In the case of a cylindrical shell, if the temperature distribution was assumed to be uniform through the wall, but to vary linearly along the axis, no appreciable stress would be produced away from the ends. But if the ends were constrained in any way high stresses could occur there. In 1926 some experiments were carried out on the heating of a turbine cylinder end. The cylinder was set up on end and heated by means of gas rings to a maximum temperature of 400 deg. Cent. at the high-pressure end. The heating was quite slow, taking about two hours to get to the full temperature. After cooling down the cylinder was unbolted and measurements of the distortion showed it to be of a kind shown in the paper, with an increase of about 0·015in on the vertical diameter of 46in and a decrease of about 0·02in on the horizontal diameter and a gap on the inside of the flange varying from 0·010in to 0·018in. Those heating and cooling cycles were repeated a number of times and they showed that the distortions due to the subsequent heatings were quite small compared with the first one. In fact, after three cycles no further appreciable distortion took place.

Dr. N. P. Allen said that the paper on the thermal distortion of turbine casings was rather interesting as illustrating a general point of some importance, which was that the problems of design could very often be eased by improvements in materials and likewise improvements of design could ease materials problems. The problems were always double-barrelled ; there were always a materials aspect and a design aspect. In that connection he wished to draw attention to the values of the T_W numbers in Table 6, which represented the susceptibility of a material to distortion, on heating essentially. It was very interesting to see how great the variations were. If they did represent the susceptibility of the material to distortion, the figures showed that a great deal could be done by suitable choice of material to reduce the distortion problem. One conclusion that seemed to be obvious from the figures was that, as in raising the temperature they had become obliged to go to oxidation resistant materials, one should make the most of the critical 10 per cent chromium steel, which was good in that respect, before going on to the austenitic steel which was so inconspicuous in that respect on those figures. The figures for the 12 per cent chromium-molybdenum-vanadium steel were disappointing in the high maximum permissible stress quoted. To some extent they were on the lower coefficient of expansion. That was rather important because it was due to the admixture in the steel of a certain amount of chromium, and the chromium had a lower coefficient of expansion than iron. That seemed to be a direction in which to move. There seemed to be some improvement there, but it was chiefly due to the high maximum permissible stress. Were those figures really relating to the properties of castings such as might be used in a turbine casing or were they typical of forged steel materials of that kind ? The steel was customarily heat-treated to get the properties displayed in the table and it might be that those properties were by no means so easily obtained in an actual casting as in the small forged part. If the figures were indeed the properties of a casting, it seemed that a great easement of the thermal distortion problem could be obtained, but if the properties were those not of an actual casting but of a typical material of that kind, it must be concluded that the improvements were possible but had not yet been achieved, the figures simply showing what improvements could be obtained if the subject were studied metallurgically, although it could not be said that the improvement in behaviour could yet be achieved.

Mr. P. D. Morris had always held firm to the view, and still did so, that when the marine gas turbine was ultimately developed it would have many closer resemblances in general construction to its flying ancestor than were yet apparent. He had been strengthened in that view by Dr. Brown's interesting reference to the adventurous research of the Pametrada group in the use of very high cycle temperatures of 2000 deg. Fah. The use of such temperatures must lead to a vast reduction in engine size choices, and the relative stabilisation of casing temperatures must result in simpler construction, which would reduce thermal expansion and distortion troubles. The paper by Mr. Terrell on the thermal distortion of turbine casings was a most interesting contribution to the art, one which had not received much attention in the literature up to the present time. Experience at the National Gas Turbine Establishment bore out much of Mr. Terrell's philosophy. One method of reducing thermal distortion in split casings which had been tried out was worth mentioning. It was simply a matter of dividing the casing axially into a number of sections to get split sections on the horizontal and vertical axis respectively, creating a sort of balance of power in which the distortions through heating and cooling in adjacent sections of the barrel opposed each other. The stresses involved were thus relatively small. Another method adopted on an experimental turbine at the N.G.T.E. was the use of a double casing in which the outer casing was of robust construction having a number of internal passages which could be heated or cooled by a small subsidiary low-pressure air supply. The temperature and the thermal expansion of the outer covering could be controlled and stabilised. The inner casing was of light segmental construction supported from the outer casing. Such an arrangement allowed the clearances to be controlled by adjusting the temperature of the outer casing. Such a construction was valuable for the particular experimental turbine of which he spoke, although the complexity of construction might make it unattractive for marine use. He mentioned it because it appeared to embody a principle in respect of which development was still possible.

Mr. D. G. Ainley suggested that Dr. Brown had been unduly modest in his remarks. He had inadequately emphasised the tremendous value which accrued to the whole of the design and research staff at Pametrada when troubles arose on the test bed, troubles which might occur in units other than those of their own design. Nor had he touched upon the fact, adequately, that by the close co-operation existing between the Association and the member firms, the staff became intimately aware of production difficulties and defects arising on sea trials and on service. In this way owners were usually very co-operative, and it was as natural to take the superintendent to the research station as it was to take him to the drawing-office. Assisting in this feed-back of knowledge were the various committees and boards regulating research, these being drawn from the industry and representative authorities. The progressive total of this experience was rapidly leading to Pametrada becoming possibly the greatest authority on marine turbine design. Nor was this experience thwarted by any attitude of undue conservatism, although they knew that a degree of conservatism was essential to the economic well-being of a marine fleet. The correct attitude was well demonstrated by the papers, which showed progressive ingenuity of design.

Mr. J. H. Dale felt that Mr. Terrell must have overcome a great problem in getting so many running hours out of the Pametrada gas turbine with 1¾in austenitic casings. Why were they so thick ? On pressure grounds, surely a ¼in was thick enough. Suspension must be the only outside influence, and in this connection the lighter the casing the better, because there was less weight to carry. Thermal distortion was worse with a heavier casing.

The chairman, Dr. R. W. Bailey, said that he had had a great deal of experience with the problem of thermal distortion. Many turbine cylinders had been heated and the distortions measured in the way which had been mentioned by one of the speakers. In several cases there had been thermal distortion on the first heating ; in other words, one could take it that the material went through the elastic limits somewhere on normal heating up, or on something not as intense as normal heating up. So long as there was not overheating, repeated heating did not make any difference. A slide showed diagrams of three successive heatings of a turbine cylinder. The maximum temperature was about 400 deg. Fah. Efforts were made to reach about 100 deg. Fah. higher than the maximum steam temperature at the top of the cylinder. Thermo-couples were placed in various parts of the cylinder. The treatment was repeated, and after the third treatment the cylinder was unbolted and the measurements were taken. The distortion was of the order of fifteen-thousandths in the diameter measured in any two directions. In the case of the secondary heating, there was a slight increase in the case of one or two of the readings, but it was quite small ; perhaps it was two-thousandths, compared with fifteen-thousandths.

The authors replied briefly and the meeting ended.

The Newer Laminated Plastic Insulating Materials*

By A. N. HAWTHORN, A.R.I.C., and S. W. MESSENT, B.Sc., A.M.I.E.E.†

The effect of various conditions, maintained for considerable periods, on the properties of some of the more recently developed laminated sheet insulating materials is investigated. The tests are not yet complete, but in most cases they have been carried on for a sufficient time to indicate trends which it is hoped to confirm at some future date. Some other properties of the test sheets, measured in accordance with established procedure, are also included.

In recent years, new synthetic resins and fillers have been produced which are suitable for the manufacture of laminated plastics for insulating purposes. Some of these are already being used in electrical apparatus. Since comparative information about their properties is not generally available, representative types have been selected for the present series of tests.

In addition to the usual tests for mechanical, electrical and physiochemical characteristics, the effect of prolonged exposure to high temperature and high humidity on some of these properties is being determined. Although the materials available for this investigation had woven fabric fillers, it was decided to test, for purposes of comparison, two synthetic resin bonded paper base laminates corresponding to Types 1 and 3 of B.S. 1137, since these have a known standard of performance as insulating materials, and there is no comparable standard for cotton fabric filled laminates.

By varying the make-up of the filler (e.g., thickness, weave, absorbency) and the relative proportions of resin to filler, some characteristics of a laminate can be modified at the expense of others. With established synthetic resin bonded sheet insulating material the user requirements have resulted in a selection from the possible types of three paper-base (B.S. 1137) and three fabric-base (B.S. 972) laminates. In considering the data presented in the paper account should therefore be taken of the possibility that the most useful combination of properties may not yet have been formulated.

Construction of Laminates

Eleven different combinations of fillers and resins have been examined. From each combination a range of laminates of $\frac{1}{16}$in, $\frac{1}{8}$in, $\frac{1}{4}$in, and $\frac{1}{2}$in thickness was produced on a production scale.

Material 1.—A kraft paper 0·004in thick, unsized and uncalendered, made with a chemical wood pulp finish, subsequently impregnated with phenolic resin. The resin content of the sheets is 40 per cent. Such material complies with B.S. 1137 type 3.

Material 2.—A cotton rag paper, unsized and uncalendered, 0·005in thick, impregnated with phenolic resin to have a nominal resin content of 60 per cent. Such material complies with B.S. 1137 type 1.

Material 3.—A fine-weave glass fabric, 0·005in thick, woven from glass fibres substantially free from alkali, impregnated with phenolic resin to give a resin content of 50 per cent.

Material 4.—A fine-weave Terylene fabric, 0·005in thick, impregnated with phenolic resin to produce a resin content of 50 per cent.

Material 5.—A fine-weave woven nylon fabric having a nominal thickness of 0·003in, impregnated with phenolic resin to give a resin content of 50 per cent.

Material 6.—A medium-weave acetylated cotton fabric having an acetyl content of 30 per cent and a nominal thickness of 0·008in, impregnated with phenolic resin to give a resin content of 50 per cent.

Material 7.—A medium-weave acetylated cotton fabric having an acetyl content of 60 per cent and a nominal thickness of 0·013in, impregnated with phenolic resin to give a resin content of 50 per cent. The resin used for materials 1–7 was a conventional ammonia-catalysed 40 per cent metacresol-formaldehyde resin.

Material 8.—A fine-weave Terylene fabric having a nominal thickness of 0·005in, impregnated with oil-modified phenolic resin to give a resin content of 50 per cent.

Material 9.—A fine-weave nylon fabric having a nominal thickness of 0·003in, impregnated with oil-modified phenolic resin to produce a resin content of 50 per cent. (The oil-modified phenolic resin used for materials 8 and 9 consisted of an alkylated phenol-formaldehyde resin reacted with china-wood oil and catalysed with ammonia).

Material 10.—A fine-weave woven glass fabric, 0·005in thick, woven from glass fibres substantially free from alkali, impregnated with amino resin to give a resin content of 40 per cent. (Amino resin is a melamine-formaldehyde resin plasticised with urea-formaldehyde resin).

Material 11.—A fine-weave woven glass fabric, 0·0058in thick, woven from glass fibres substantially free from alkali, impregnated with silicone resin to give a resin content of 40 per cent.

[The paper then gives details of the following tests on the eleven materials : electric strength at 90 deg. Cent. as a function of thickness ; electric strength as a function of temperature ; resistance to tracking ; loss angle as a function of temperature ; loss angle as a function of moisture absorption ; insulation resistance as a function of temperature and as a function of exposure to tropical conditions ; physiochemical tests ; and mechanical tests including tensile strength as a function of temperature, impact strength after ageing, and yield in compression.—Ed. The E.]

All materials tested were of $\frac{1}{4}$in. nominal thickness. The test piece, with its three 2-B.A. electrodes spaced equilaterally at 1$\frac{1}{4}$in. between centres, was in accordance with B.S. 1137, Appendix H. The specimen was supported in the oven by the testing leads, which were of stout copper wire.

Exposure to Tropical Conditions

All materials tested were of $\frac{1}{4}$in nominal thickness. The test piece, with its three 2-B.A. electrodes spaced equilaterally at 1$\frac{1}{4}$in between centres, was in accordance with B.S. 1137 Appendix H. The specimen was supported in the oven by the testing leads, which were of stout copper wire. The electrodes were fitted and the specimen surfaces cleaned with benzene prior to conditioning. This was carried out in a tropical humidity chamber having a water vapour saturated atmosphere at a temperature of 45 $\pm$2 deg. Cent.

For testing, the specimen was transferred from the tropical chamber to a test chamber maintained at about 95 per cent relative humidity and a temperature of 25 $\pm$1 deg. Cent. The sample was supported by the testing leads in this chamber for 1 hour $\pm$2 min before the insulation resistance measurements were made. Three specimens of each material were tested, and the results are shown in Table I.

Attention is drawn to the wide range of results on any one set of three specimens, totalling nine measurements in all. The range can have a value of the same order as the average value, or may even exceed it. The test is very sensitive and care was taken to minimise known variables. The insulation resistance of the glass fabric filled laminates drops rapidly to a relatively low value. The water absorption of these materials does not differ greatly from that of the laminates with different fillers, and it would appear that the deterioration is due to water-soluble inorganic salts, dissolved from the glass, which ionise readily. A point of interest is the bleaching of the amino-glass-laminate specimens, the reason for which is not evident.

Ultimate Water Absorption

Approximately 5 g of each material ($\frac{1}{2}$in by $\frac{1}{4}$in by $\frac{1}{16}$in) were accurately weighed after conditioning for twenty-four hours at 75 per cent relative humidity and at a temperature of 20 deg. Cent. to 25 deg. Cent. These pieces constituted the sample, which was then immersed in distilled water at a temperature of 25 deg. Cent. $\pm$1 deg. Cent. Periodically the sample was removed from the bath, the pieces were dried with a clean cloth, and the sample was reweighed, the weighings being completed within two minutes of removal from the water. The sample was then immersed again in the water, and the procedure was continued until a constant increase in weight on the original value was attained. Five samples of each material were tested and the percentage increase in weight was calculated for each sample. The ultimate figure was the average of these, as given in Table II. A five-month immersion has been possible for most of the materials, but sometimes this has not been sufficient to arrive at the ultimate absorption. Sufficient information was obtained, however, for the ultimate percentage to be deduced.

For materials 8 and 11 the gain of 1 per cent was achieved in the first month, and thereafter remained constant. Material 10 showed a gain in weight of 5 per cent at the end of the first month and 2$\frac{1}{2}$ per cent at the end of the fifth. This was no doubt due to the leaching out of the urea-formaldehyde resin plasticiser. An interesting point is that the samples bleached during immersion. Where two figures are given (i.e. materials 3, 6 and 7), a three-month immersion only has been possible.

The order of the twenty-four-hour figures does not agree with that obtained during the ultimate method, but the former is adopted by the B.S.I. as a convenient control test. The phenolic resin bonded Terylene, although having a high twenty-four-hour water absorption, has a normal ultimate, and further, the one-day figure is approaching that of the ultimate figure. This, together with the pronounced increase in water absorption with thickness, indicates that water is absorbed rapidly through the edges of the laminate.

The samples of material 4 coloured the water in which they were immersed a rose pink.

Weight Loss on Heating

Each specimen, of dimensions 2$\frac{1}{2}$in by $\frac{1}{2}$in by $\frac{1}{4}$in., was weighed after conditioning for two hours at 105 deg. Cent. and then aged at the appropriate temperature in an electrically heated oven fitted with an air circulating fan. The specimen was removed and immediately placed in the desiccator to cool for one hour. It was weighed within two minutes of removal from the desiccator and then returned to the oven. Five

Table I—*Insulation Resistance (in Megohms) as a Function of Time of Exposure to Tropical Conditions*

Mater'l	Start		4 weeks		8/9 weeks		12/13 weeks		16/17 weeks		20 weeks	
	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
1	10^5	—	18	9	14	27	20	27	13	18	15	35
2	8×10^5	—	7×10^5	25×10^5	5×10^5	6×10^5	2×10^5	2×10^5	2×10^5	3×10^5	3×10^5	2×10^5
3	2×10^5	—	3·4	1·34	—	—	—	—	—	—	—	—
4	—	$3\cdot5\times10^5$ to $>10^9$	27	35	21	50	30	69	23	48	14	24
5	$>10^4$	—	9×10^4	4×10^4	5×10^4	3×10^4	3×10^4	$2\cdot5\times10^4$	5×10^4	3×10^4	8×10^4	3×10^4
6	8×10^5	—	2×10^5	$3\cdot5\times10^5$	9×10^5	7×10^5	8×10^5	$1\cdot3\times10^5$	—	—	—	—
7	$>10^4$	—	2×10^5	2×10^5	—	—	—	—	—	—	—	—
8	—	8×10^5 to $>10^9$	6×10^5	6×10^5	8×10^5	—	6×10^5	$7\cdot5\times10^5$	7×10^5	6×10^5	7×10^5	5×10^5
9	—	$3\cdot5\times10^5$ to $>10^9$	4×10^4	2×10^4	2×10^4	—	2×10^4	10^4	10^4	10^4	10^4	10^4
10	8×10^5	4×10^5	19	16	14	17	4	8	1·8	1·7	1·9	2
11	3×10^5	3×10^5	21	14	11	10	14	17	11	11	12	7

Table II—*Ultimate Water Absorption*

Material	Average density (range for four thicknesses)	Ultimate water absorption per cent
1	1·370–1·381	17½
2	1·285–1·299	5
3	1·734–1·755	2–2½
4	1·301–1·306	3·5
5	1·182–1·186	4
6	1·286–1·295	4–4½
7	1·234–1·253	3½–4
8	1·243–1·253	1
9	1·126–1·136	4½
10	1·923–1·939	—
11	1·716–1·733	1

* Abstracts. "The Properties of Some of the Newer Laminated Plastic Insulating Materials" from a Symposium of papers on Insulating Materials. The Institution of Electrical Engineers, London, March 16–18, 1953.

† The Micanite and Insulators Company, Ltd.

specimens were tested and the average percentage loss in weight was calculated.

Materials 1 and 2 darkened considerably at 100 deg. Cent. and 150 deg. Cent., but the layers were still well bonded at both temperatures. Exposure to a temperature of 200 deg. Cent. for twenty-four hours caused blistering and cracking along the layers.

Materials 4 and 8 also darkened. Material 4 increased in weight at 100 deg. Cent. for the whole period of five months, and for two months at 150 deg. Cent., after which it lost weight. At temperatures of 150 deg. Cent. and 200 deg. Cent. the resin bond has very little strength, so that the layers can be readily separated. Material 8 showed interlaminar cracks after two months at a temperature of 150 deg. Cent., and the specimens exposed to a temperature of 200 deg. Cent. were swollen after twenty-four hours. Exposure to a temperature of 100 deg. Cent. resulted in a gain in weight.

Materials 5 and 9 darkened, but the layers were still well bonded after exposure to a temperature of 150 deg. Cent. Material 5 was swollen and showed layer cracks after twenty-four hours at a temperature of 200 deg. Cent. Material 9 swelled at a temperature of 150 deg. Cent., exhibiting a few cracks, and showed the same defects more markedly after twenty-four hours at a temperature of 200 deg. Cent. This may to some extent be due to insufficient experience in the use of oil-modified phenolic resins for laminating.

Materials 6 and 7 showed marked distortion and shrinkage at 200 deg. Cent., particularly material 7. The laminæ, however, were still well bonded.

Material 10 has a very high loss at 150 deg. Cent. There is some surface blistering, but the layers are still well bonded. At 200 deg. Cent. the specimens had swollen appreciably. At all temperatures the colour of the specimens had changed from brown to almost white.

Material 11 was not apparently affected by exposure to any of the temperatures.

TABLE III—*Schedule of Performance*

Test	Material										
	1	2	3	4	5	6	7	8	9	10	11
Electric strength/temperature	G	G	F	Ex	F	G	G	Ex	F	F	Ex
Electric strength/thickness	G	G	F	Ex	F	F	G	Ex	F	F	G
Loss angle/temperature	F	G	G	G	F	G	G	G	F	P	Ex
Loss angle/moisture	P	F	P	G	F	P	G	Ex	F	F	P
Insulation resistance/temperature	F	F	F	G	P	F	G	G	P	P	Ex
Insulation resistance/tropical humidity	P	F	P	P	G	G	G	Ex	G	P	P
Resistance to tracking	P	P	P	P	P	P	P	P	P	G	Ex
Tensile temperature :											
100 deg. Cent.	F	F	Ex	Ex	F	F	F	P	P	G	F
150 deg. Cent.	P	P	G	Ex	F	P	P	U	U	P	G
200 deg. Cent.	P	P	P	P	P	P	P	U	U	P	G
Tensile ageing :											
27 deg. Cent.	Ex	F	G	P	F	F	P	F	G	Ex	Ex
100 deg. Cent.	F	P	—	P	F	—	—	F	F	Ex	G
150 deg. Cent.	P	P	—	P	P	—	—	P	P	F	G
200 deg. Cent.	U	U	—	—	—	U	—	—	—	U	Ex
Impact ageing :											
27 deg. Cent.	F	P	G	P	G	F	F	P	G	G	Ex
100 deg. Cent.	F	P	G	P	G	F	—	P	G	Ex	Ex
150 deg. Cent.	P	P	G	P	F	P	—	P	F	G	Ex
200 deg. Cent.	U	U	—	U	U	U	U	U	U	U	Ex
Compressive yield	G	G	F	F	F	F	—	P	—	G	G
Ultimate water absorption	F	G	G	G	G	G	G	Ex	G	P	Ex
Cost ratio	1	2	9	20	20	5	6	20	20	9	15

Ex = Excellent. G = Good. F = Fair. P = Poor. U = Useless.

Conclusions

At some risk of over-simplification, Table III has been prepared to provide a comparison of the laminates tested.

None possesses all the attributes desired for an insulating board or sheet. The effect of varying the proportions of resin to filler can be seen by comparing the characteristics of the paper-base laminates, although it should be remembered that another variable is present in the two types of paper filler used. A different ratio of resin to filler in the other laminates would alter their properties, and the most suitable combinations may not have been achieved.

The cellulose-filled laminates are at present the most widely used, and are comparatively straightforward to produce owing to the chemical and physical structure of the fibres, which are readily wetted by most synthetic resins. Cellulose fibres, however, absorb moisture with consequent dilation, and are lacking in thermal stability. The acetylated cotton fabric fillers are of interest, in that they produce laminates which maintain a high insulation resistance in tropical conditions. They also have much better electrical characteristics than the conventional cotton fabric laminates, although at the expense of the mechanical properties.

In general, the glass fabric filled laminates possess good mechanical properties and thermal stability but suffer a serious deterioration of electrical characteristics in humid conditions. This is probably due to inadequate wetting of the glass fibres with consequent lack of bonding by the resin. Recently, methods of sizing the glass fabric have been evolved using compounds which replace the surface hydroxyls of the glass fibre by organic groups which facilitate wetting by the resins. The efficacy of these is being explored.

The silicone resin bonded glass fabric laminate has most of the requirements of an insulating board with the exception of its poor behaviour in humid conditions.

The amino resin bonded glass laminate represents an attempt to improve upon the electrical characteristics obtained with a straight melamine-formaldehyde resin. The inclusion of the urea-formaldehyde resin plasticiser leads to an unusual pattern of behaviour during some of the long-duration tests. Further development appears possible and is being pursued. Only the silicone and amino resins confer resistance to tracking.

Although tests are incomplete on the phenolic resin bonded glass laminate, it does not appear to have any advantage over the silicone or amino bonded glass materials.

The synthetic fibre filled laminates are interesting. The two Terylene laminates have very good electrical properties, but their mechanical characteristics are poor. This low strength may be due to a chemical combination of resin and filler, since it is known that some phenols react with Terylene under certain conditions. That something has occurred is evidenced by the pink coloration of the water used in the water absorption tests. An improvement in mechanical strength is very desirable, and would appear to require the use of a different type of resin bond. This is being investigated. The nylon laminates have better mechanical strength but inferior electrical properties.

The scope of the investigation was not sufficiently detailed to enable the temperature limitations of the various laminates to be assessed closely. The only material which withstands a temperature of 200 deg. Cent. satisfactorily for any length of time is the silicone resin bonded glass laminate. All the other materials withstood a temperature of 100 deg. Cent. reasonably well, whereas 150 deg. Cent. is too high, except perhaps for short-time exposure in the case of nylon and glass-filled laminates.

Exposure to high humidity for a long time did not cause appreciable thickness swelling except in the case of the paper-filled laminates.

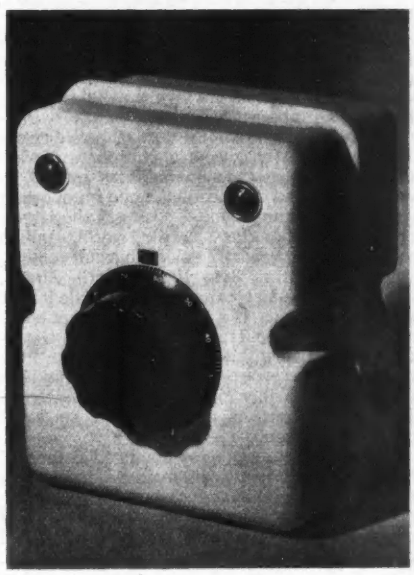
Included in Table III are figures indicating the relative cost of the various laminates. The thickness of a fabric filler can considerably affect its cost, as well as modifying the characteristics of the laminate.

An Electronic Thermostat

THE thermostat illustrated herewith is designed to provide warning of a deviation from a required temperature or, in instances where "on-off" control is satisfactory, to maintain temperature at a preset level, provided that no indication or record is required. It is made by Fielden (Electronics), Ltd., Wythenshawe, Manchester, and consists essentially of a Wheatstone bridge circuit for use with a precision resistance bulb.

The bridge is balanced by a slide wire and slider, which is preset manually by a calibrated dial at the desired operating temperature. An alternating voltage is applied to the bridge and the out-of-balance voltage is amplified by a high-gain, phase-sensitive amplifier, the output from which operates a relay. Two indicating lamps are fitted—a green one to show when the temperature falls below the control level and a red one to show when the temperature rises above this level.

Four ranges are available, namely, —200 deg. to 0 deg. Cent., 0 deg. to 200 deg. Cent., 0 deg. to 100 deg. Cent., and 100 deg. to 500 deg. Cent. The standard relay will interrupt 5A at 230V a.c. A small die-cast aluminium case, suitable for wall mounting, accommodates the electronic equipment. The thermostat is a.c. mains fed and, to complete the installation, it is connected by copper cable to a suitable resistance bulb and pocket inserted at the point where the temperature is to be measured. The equipment described is calibrated for use with Weston standard platinum resistance bulbs.



An Electronic Thermostat

A distinct variant of this equipment, made by the same manufacturer, employs a similar Wheatstone bridge circuit and constitutes a temperature measuring instrument. In this instrument an alternating voltage is applied to the bridge circuit and the out-of-balance voltage is amplified and made to operate an electronic indicator of the kind popularly known as a "magic eye." The scale dial is rotated until the bridge is balanced, as shown, by the electronic indicator and the dial reading then gives the temperature. The instrument is generally similar in appearance to the electronic thermostat illustrated herewith, except that there is an electronic indicator in place of the left-hand indicator lamp. The same four temperature ranges are available.

INTERNATIONAL CONGRESS OF REFRIGERATION.—The eighth International Congress of Refrigeration was held in London in August and September, 1951. Its *Proceedings* have now been published in a single volume costing £3. Copies may be obtained from the secretary of the Congress, whose address is the Institute of Refrigeration, Dalmeny House, Monument Street, London, E.C.3.

Indian Engineering News

(By Our Indian Correspondent)

Indian Rare Earths

The mineral sands of the beaches of Travancore-Cochin in the south of India contain large quantities of rare earth minerals like ilmenite (60 to 75 per cent), monazite (1 to 4 per cent), zircon (3 per cent), sillimanite (7 per cent) and garnet (1 to 3 per cent). The occurrence of monazite in these deposits was discovered accidentally by a German chemist, C. W. Schomberg, in 1909, and the discovery was followed almost immediately by an investigation by the Geological Survey of India. Exports began in 1910 and by 1937 had reached an annual figure of 5000 tons. In April, 1948, an Atomic Energy Commission was set up to advise the Government on the exploitation of rare earth minerals, and on its recommendation it was decided to set up a plant for processing monazite and to ban all exports of the untreated mineral. Consequently the Government entered into an agreement with the Société de Produits Chimiques des Terres Rares by which the latter agreed to provide the necessary technical knowledge and assistance for the setting up of a factory for processing 1500 tons of monazite annually. The factory now in production was inaugurated last December by the Prime Minister, Mr. Jawaharlal Nehru.

The Travancore ilmenite is rich in titanium dioxide, which forms the base of many high-grade paints, lacquers and varnishes and also constitutes a valuable ore for the metal titanium. Before 1939 about 75 per cent of the world's requirements in titanium were supplied from Travancore. Monazite is a phosphate of rare earths containing thorium oxide as one of its constituents and is one of the most important sources of thorium. India possesses the largest reserves of monazite in the world, Indian monazite being specially rich in thorium content, which varies from 8 to 10 per cent. Zircon, another rare metal compound associated with the ilmenite sands, is a silicate of the rare metal zirconium and the Travancore variety also contains minute quantities of uranium. The total reserves of these rare earth minerals have been estimated at roughly 250 million tons of ilmenite, 1·5 million tons of monazite and an equal quantity of zircon.

The factory can process about 1500 tons of monazite sands a year, its main products being rare earth chlorides and carbonates. The by-products are between 1500 tons to 1800 tons of trisodium phosphate and 900,000 gallons of caustic soda lye in 10 to 12 per cent solution. The residue, after all this extraction, when suitably treated, can yield about 220 tons of thorium nitrate. This residue will be treated by a factory to be set up by the Atomic Energy Commission for the production of uranium and thorium compounds.

Ports and Harbours

The Planning Commission has approved a plan for the rehabilitation and modernisation of the five existing major ports, namely, Bombay, Calcutta, Madras, Visakhapatnam and Cochin, and the construction of a sixth at Khandla in Saurastra. The plan, when completed at an estimated cost of about Rs.50·62 crores (£40,000,000), will increase the present capacity of roughly 20 million tons of shipping per annum by 25 per cent and relieve congestion at these ports, particularly at Bombay, which, since partition and the loss of Karachi, has not been able to meet the increased demand of post-war shipping. The proposals for Bombay, estimated to cost Rs.18·11 crores (£13·5 million), include the construction of a lock connecting the Princess and Victoria Docks with Alexandra Docks (Rs.4·30 crores), reconstruction of transit sheds in the same docks (Rs.2·11 crores), installation of thirty-four electric cranes at Alexandra Docks (Rs.1·5 crores), reorganisation of the entire electric distribution system (Rs.80 lakhs) and labour housing (Rs.1·4 crores). An additional Rs.8 crores will be expended on providing a new dockyard at Trombay for the new oil refineries now under construction. Calcutta has been allotted Rs.11·8 crores for the provision of extra berths, Madras will receive Rs.4·75 crores for a new four-berth dock, Cochin and Visakhapatnam will spend Rs.2·28 crores and Rs.68 lakhs, respectively, on the provisions of four cargo berths to increase the capacity by a million tons. Khandla, a badly needed new port on the west coast of India, has been allotted Rs.13 crores. The development plan has been accorded high priority and Mr. Lal Bahadur Shastri, Minister for Railways and Transport, has announced that the plan will not be held up for lack of funds. In addition to this, it was announced from New Delhi that the Government of India has entered into a contract with Sir Alexander Gibb and Partners of London, who will act as their consulting engineers for the new naval dockyard at Bombay. The ultimate cost of this defence project is estimated at Rs.20 crores, of which the first stage is expected to be complete by 1958, at a cost of about Rs. 6 crores.

Under the Constitution, the responsibility for major ports is vested in the Central Government, while all other ports are administered directly by state governments. There are about 200 such minor ports distributed along the country's 4000-mile-long coastline. They are mostly roadsteads, where ships have to anchor some distance from the coast and goods are handled by means of lighters.

The development of these ports is bound up with that of roads and other means of communication on land, and some of the state plans for road development are expected to go a long way towards modernising and increasing the capacities of these neglected roadsteads.

Of the five major ports, Calcutta, Bombay and Madras have, for long, been under the management of statutory Port Trusts modelled on the Port of London Authority, and the ports of Visakhapatnam and Cochin are directly administered by the Central Government through Administrative officers. Port Trusts enjoy a large measure of autonomy in day-to-day affairs, but are subject to the overall control of the Central Government, exercised in terms of a Port Trust Act, governing each of the three ports. All the five major ports constitute national undertakings, the capital value of whose assets at the end of 1950–51 stood at over Rs.82 crores. These ports handled 18·85 million tons of goods during the financial year 1950–51.

Bombay

The Port of Bombay has a magnificent natural harbour, which was described even three hundred years ago as " the fairest, largest and securest in all the ports of India where a hundred sails of tall ships may arrive all the year, safe with good anchorage." During 1950–51 the port was used by 1104 steamers engaged in foreign trade with a net registered tonnage of 4,985,910 ; 4602 coastal vessels with a tonnage of 2,034,486, and 49,828 sailing vessels with a net tonnage of 921,109. The port handled in all 6887 million tons of cargo during the year, of which 5185 million tons were imports and 1702 million tons were exports. The average turn-round of shipping in the port during the fortnightly periods between January and August, 1952, has varied from 4·4 to 8·5 days and only rarely has a ship had to wait for a berth in stream. The total revenue during the year was Rs.6·58 crores, as against the expenditure of Rs.6·04 crores. Traffic operations accounted for 35·38 per cent of the expenditure, administration 12 per cent, debt charges 12 per cent, and dredging and maintenance 19·6 per cent. The dock system is rather out-dated and modern ships are not able to use the Princess and Victoria Docks round the clock. The explosion of 1944 followed by the severe strain due to partition has left behind a backlog of maintenance and repair work which can be undertaken successfully only in conjunction with the modernisation and development schemes sanctioned by the Government.

Calcutta

Calcutta is the principal exporting port for the country and last year handled 7·5 million tons of cargo, nearly 600,000 tons more than Bombay. It suffers from the inevitable disadvantages arising out of its location several miles inland on the bank of the estuarine Hooghly, which is subjected to strong tides and bores to a distance of 150 miles upstream. About 70 million cubic yards of silt are brought to the river every year, thereby limiting the size of the largest vessels capable of travelling up the river. Draft restrictions on ships entering the river have, therefore, become inevitable and ships often have to lighten their load at Madras or Visakhapatnam before reaching Calcutta. Lack of appreciation of these natural difficulties has resulted in periodical criticisms and pessimistic forebodings regarding the future of the port, but the Port Commissioners are making strenuous efforts to maintain the depth of the river at adequate levels (THE ENGINEER, July 4, 1952). During the year 1951–52 the port was visited by 882 steamships with a net registered tonnage of 3,389,200 employed in foreign trade, and 295 steamships engaged in coasting with a tonnage of 819,347. The port handled 7·5 million tons of cargo during the year, of which exports (including jute, coal, tea and iron ore) amounted to 4·5 million tons. The maximum available capacity for coal handling in the port is 14,500 tons a day, the effective capacity being about 12,000 tons. The financial year 1950–51 ended with a deficit of Rs.52 lakhs, the income being Rs.6·91 crores, against the expenditure of Rs.7·43 crores. Of these, establishment charges accounted for Rs.1·6 crores and debt charges Rs.1·40 crores.

Madras

Madras is comparatively a small harbour with limited capacity and last year it handled 2·17 million tons of cargo, less than a third of Bombay. During the year 768 steamers (tonnage 3·184 million tons) engaged in foreign trade visited the port in addition to 228 coasting steamers with a tonnage of 546,413. The revenue for the year was Rs.1·21 crores and expenditure Rs.76·14 lakhs, thus leaving a substantial surplus. A start has already been made on the first stage of the Five Year Plan, which is expected to cost Rs.1·15 crores.

Cochin

Although Cochin is the youngest of the major ports so far opened, from the point of view of tonnage and financial resources it occupies the fourth place. It has a fine natural harbour, giving access to 125 square miles of navigable backwaters and even in the worst monsoon weather ships can lie comfortably in the harbour and carry on landing and shipping operations. Last year 871 steamships (foreign and coastal) with a total tonnage of 2,333,866, visited the port, in addition to 287 sailing vessels with a tonnage of 22,228. During that year the port handled 1·34 million tons of goods, food grains forming a large part (426,000 tons) of the cargo. The total revenue was Rs.59·88 lakhs and the expenditure Rs.57·01 lakhs, of which traffic operation accounted for 19·26 per cent, debt charges 23·75 per cent, the balance being shared by such items as administration, maintenance, &c. It is proposed that most of the traffic passing through the port should be handled at the wharves and not in private jetties as is the case at present. A continuous reinforced frontage to the wharf has recently been completed at a cost of over Rs.42 lakhs and this has eliminated the use of fender pontoons between the ship and the wharf. It has been decided to provide an oil berth in the Ernakulam channel and to have certain other oil installations for black oil on Wellington Island.

Visakhapatnam

Visakhapatnam port has a sheltered inside harbour but it suffers from a handicap in that the entrance channel cannot be relied on always to take ships exceeding 28ft in depth or allow a ship exceeding 570ft in length to pass in safety. Although, geographically, the port is well placed the hinterland is not very well developed. With the construction of Hirakud dam on the Mahanadi River in Orissa, however, it is likely that the port's traffic will increase considerably. During the year 1950–51 330 foreign-going ships with a tonnage of 1,270,791 and ninety-four coasting vessels with a tonnage of 259,975 visited the port. 945,000 tons of goods were handled by the port, of which manganese and other ores alone accounted for

625,000 tons, just over 71 per cent of the total exports of 878,000 tons. Visakhapatnam has from its inception been a deficit port but the deficit has been gradually decreasing and last year it amounted to Rs.2·01 lakhs only.

By and large the labour situation in Indian ports has been satisfactory during the last two years. A recent survey of the conditions of labour employed in the principal ports indicates that there are over 42,000 workers employed directly, out of whom 34,000 are permanent. There has been all-round improvement in the conditions of workers in the ports and most of them have been brought within the ambit of the Minimum Wages Act. A scheme for "decasualisation" of stevedore labour is already in force in Bombay and will shortly be introduced in Calcutta. A similar scheme is also under consideration for the port of Madras.

Damodar Valley Corporation

The Bokaro thermal power station of the Damodar Valley Corporation was opened by the Indian Prime Minister, Mr. Nehru, on 21st February, exactly three and a quarter years after the first sod was turned on the site. The station is the first of the Damodar Valley projects to be commissioned and marks a step forward in the completion of India's first multi-purpose river valley project. The following day the first hydro-power station of the Corporation, at the Tilaiya dam, was also inaugurated by the Prime Minister, thus completing the first phase of the valley authority's five year plan, scheduled to produce 274MW of power and to irrigate about 600,000 acres by the end of 1956.

The Bokaro power station, with an initial capacity of 150MW and an ultimate one of 200MW, is the most modern of its type in India and probably in Asia. It burns low grade coal with an ash content varying from 26 to 31 per cent, thus helping in the conservation of the country's estimated high-grade coal resources of about 2000 million tons. The plant is laid down on the unit system of each generating set with two boilers, each of which is supplied with two coal burners. Steam generating units are of 300,000 lb per hour capacity, pulverised coal-fired, consisting of two-drum bent-tube boiler and a water-cooled furnace manufactured by the Combustion Engineering Super-heater Inc., U.S.A., and supplies steam at 900 lb per square inch and 910 deg. Fah. Owing to the high ash content a sluicing system has been adopted for ash-handling. The 50MW turbines, of which three have been initially installed, are General Electric single-cylinder, impulse, multi-stage, five-stage bled-steam condensing turbines directly coupled to and driving hydrogen-cooled electric generators with direct connected exciters. The turbines operate at 3000 r.p.m., and are designed for normal steam conditions of 850 lb gauge, 900 deg. Fah. total temperature and 28·3in Hg vacuum. The main transformers are rated 65,000kVA, three-phase, 13·2kV–138kV, delta-star connected with an earthed neutral, forced oil, water cooled, with external heat exchangers. All transformers are installed outside the building.

The station was designed and supervised by the Kuljean Corporation, U.S.A., and constructed by the International General Electric Company, U.S.A. Part of the capital cost estimated at about £11,000,000, has been met by the World Bank loan of 18·5 million dollars. Last month another loan was given by the World Bank to the Corporation for financing other schemes under the project.

Tilaiya dam is comparatively a small dam, about 90ft high above river bed with a total storage of 320,000 acre-feet, of which just under a half is flood storage. It is mainly a flood control project with an initial power capacity of 4000kW, which ultimately may be increased to 6000kW. It will irrigate about 24,000 acres of Kharif crop and 75,000 acres of Rabi crop. It has so far cost about £3,000,000.

The first stage of Damodar Valley includes the construction of three more dams, Konar, Mithon and Panchet Hill, a barrage at Durgapur and nearly 480 miles of 132kV, 66kV and 33kV transmission lines. All are in an advanced stage of completion and so far it has been possible to maintain the progress schedule for completion by 1956.

The Development of a Marine Steam-Turbine Design

By H. G. YATES, M.A.*

No. II—(*Concluded from page 389, March 13th*)

This is an abridgement of one of the papers presented at a "Conference on Steam Turbine Research and Development," held by the Institution of Mechanical Engineers in London last Friday, March 6th. The history of the development of steam-turbine designs at the Pametrada research station is outlined and an attempt is made to set down the functions aimed at in a design and the reasons for adopting particular configurations and methods of construction. The first of a series of turbine installations is illustrated and described, and the further development that has been carried out during the six succeeding years is illustrated by recent drawings. The paper ends with a comparison of various machinery configurations for vessels of different kinds, with installed horse-power capacities ranging from 400 to 60,000 s.h.p. per shaft.

Low-Pressure Turbine.—The low-pressure turbine shown in Fig. 2 *ante* is also of double-casing type. The inner casting supports blade-carrying rings in which the diaphragms and fixed blading are located. This enables collecting belts for bled steam to be conveniently formed without objectionable core cleaning operations. The rotor is of the "gashed" type, made from a solid forging, and carries five rows of impulse blading followed by five reaction rows. The distinction between impulse and reaction blading

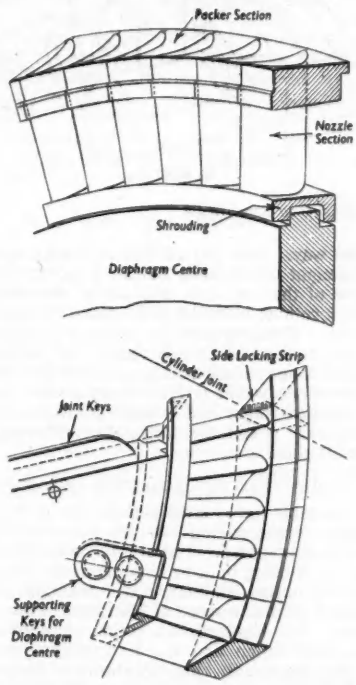


FIG. 4—*Built-up Diaphragm of Segmental Type*

is not apparent in the drawing, because of the type of diaphragm construction employed, which will be described in more detail later. The use of a gashed rotor, together with a greater proportion of impulse blading, reduces the leakage losses in early stages. For the same reason it has been possible to increase the diameter of early stages without sacrifice of efficiency, and this has resulted in a shortening of the low-pressure turbine by about 2ft, with a corresponding gain in robustness and reduction of weight.

The construction also shows to advantage in another way, which is not immediately apparent. In marine installations it is necessary to examine in detail the torsional vibrations that can be excited, either by the blades of the propeller moving in a non-uniform wake from the ship, or by other causes. The first of the critical speeds of this type is usually so low that it is of little consequence, but in the case of aft-engined installations, such as tank-ships, the first critical speed may exceed half of the normal full-power speed. This is entering on the speed range normally required in service, and is therefore of some importance.

At the critical speed, the distribution of alternating torque caused by vibration is generally very unequal between high and low-pressure trains, more than 80 per cent of it usually occurring in the low-pressure train. At the same time, the steady torque in the low-pressure train at this speed is rarely more than 30 per cent of the total. The torque variation arising at the propeller, when magnified by resonance, produces an alternating torque of about three-quarters of the steady torque. Consequently, tooth separation, manifested by rattling and hammering in the gears, is likely to be experienced. The principal factor controlling the distribution of vibration torque between the two trains in an articulated gear is the relation between the moments of inertia of high-pressure and low-pressure turbines. Consequently the considerable reduction in inertia obtained by the gashed rotor construction is of great benefit in reducing the severity of vibration at the first critical speed.

Diaphragms.—The turbines of Figs. 1 and 2 also incorporate an improved method of constructing impulse-turbine diaphragms, which is shown in more detail in Fig. 4. The nozzle blades are cut to length from rolled strip and spaced by packing pieces ("packers"), which are also of rolled section. Adjoining blades and packers are made up into packets or segments of convenient length, usually comprising about six blades, and brazed together to form one complete segment, after the manner of the fixed blading of Parsons reaction turbines. The inner ends of the nozzle blades are provided with tenons, which engage holes punched in an internal shrouding strip of deeply channelled section. The tenons are subsequently riveted over and hand brazed in addition. The segments are secured in the turbine cylinder by an encastered fixing designed to require minimum groove depth.

Since the steam loading acts only in the downstream direction, the encastering action may be provided by a toe that engages with a recess machined in the upstream face of the cylinder groove. The segments are secured in the groove by locking strips inserted peripherally. The diaphragm proper therefore consists merely of a plate split on the horizontal centre-line and having a spigot which engages the channel in the shroud. Radial keys for location of the diaphragm in the shroud ring are provided on the upstream face.

This construction is at once stronger, cheaper and more efficient than the original construction in which the nozzle segments were milled from solid bar. The milling time is naturally greatly reduced; the additional strength arises from the fact that part of the steam load is carried directly on the encastered segments and the load on the diaphragm proper is therefore reduced. In diaphragms of the original type, some restrictions are placed on the nozzle profile in order to simplify the milling operations. With the new type, no such restrictions arise, as it is a simple matter to make rolls for any desired section. Tests have confirmed the improvement in strength and performance. This construction is already in service in several ships and is to be used in a large number of ships under construction.

In the design illustrated in Figs. 1 and 2, the astern turbine is split into two sections, one carried on each of the ahead turbine shafts. In order to avoid increasing the length between supports of the high-pressure inner casing, and also the provision of internal glands remote from the ends of the casing, the astern turbine is located outside the rotor journals. Its blading is carried on a disc integral with the ahead rotor, but it is housed in a completely separate external casing supported in such a manner as to maintain axial alignment. This turbine develops about one-third of the total astern power, the remainder being developed in the low-pressure astern turbine—which is housed in a separate inner casing within the low-pressure outer casing. This construction is considered suitable for very

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high steam-temperatures and has the further advantage of reducing the span between low-pressure turbine bearings by removing part of the astern blading from the low-pressure turbine. It also helps in evening out still further the distribution of vibration torque at the first critical speed. The overhung type of high-pressure astern turbine is already performing satisfactorily in service.

Single-Cylinder Turbines

The design of high and low-pressure turbines whose development has been described is considered to be the most efficient design available for marine turbines. There is, however, a good deal to be said for the use of a simpler type of turbine, even if at the expense of a small reduction in efficiency. This applies particularly to cross-channel vessels on a short sea route, where the time of passage is too short to allow the boiler and turbine plant to reach steady conditions for more than a fraction of the total voyage time.

With this in view, the single-cylinder turbine shown in Fig. 3 was developed. Its performance in service was so satisfactory that further consideration has been given to the use of this type of turbine in ocean-going vessels. The construction shown in Fig. 3 closely resembles that used in the high-pressure turbine illustrated in Fig. 1, though in fact it preceded it in time. In this case the effect of the double-casing construction in reducing the change of gland clearances due to distortion is even greater, since the outer casing is maintained at vacuum temperature by the condenser.

The turbine of Fig. 1 runs with a steam temperature in the space between the two casings of 300–400 deg. Fah., dependent upon the inlet temperature of live steam. Since it is the outer casing that constitutes the beam supporting the inner barrel and maintaining the gland bores coaxial with the shaft, the permissible gland clearance depends primarily upon the likelihood of thermal distortion in the outer casing. While this is likely to distort much less than the barrel of a single-casing turbine of the ordinary type, because there is a temperature of 300–400 deg. Fah. instead of a mean temperature of about 600 deg. Fah., nevertheless, some distortion must occur.

In the single-cylinder turbine of Fig. 3, the temperature of the outer casing will rarely alter by as much as 50 deg. Fah. during power changes and thermal distortion due to temperature changes will consequently be very greatly reduced. In the first turbine of this type to operate in service, the bearing centre-distance was 84in. The designed gland clearance throughout the turbine was 0·015in. The actual gland clearance, as measured in the maker's works, was as low as 0·009in in several places, not only in the external glands but also in the main internal and diaphragm glands. Nevertheless, after a year's operation, in a service requiring frequent stops and starts, the glands were found to be in perfect condition and had obviously not rubbed. This affords valuable confirmation of the designer's expectation that this particular form of double-casing construction will enable a very appreciable reduction in gland clearances to be made without in any way impairing the robustness of the turbine and its reliability in service. If such a reduction in gland clearance can be made, it puts a new complexion on the whole problem of obtaining efficiency in turbines of moderate size and may well bring the performance of the single-cylinder turbine level with that of the compound arrangement, except perhaps for steam pressures above current values.

The turbine of Fig. 3 has another advantage in that the hottest parts of both the ahead and the astern turbines are closely adjacent. The inlet belts are located in the same plane towards the centre of the turbine length, with the ahead nozzles in the upper half, and the astern nozzles in the lower half, of the inner barrel. This ensures that when the ship is running ahead the walls of the astern nozzle box are maintained at a temperature above the figure at which condensation would be produced on admitting astern steam. Additionally, the construction affords some saving in length.

The main high-pressure gland, fitted internally between ahead and astern turbines, is carried in a diaphragm supported on radial keys in the usual way. One pair of palms, which supports the weight of the inner barrel, is located in the plane of the inlet belt, and one of the athwartship locations is in the same plane beneath the barrel. Concentricity of gland and shaft is therefore ensured at this most vital point. A pocket is provided, part-way down this gland, from which steam is fed through holes drilled in the diaphragm and is returned to the ahead turbine at a suitable stage, thus reducing the overall gland loss.

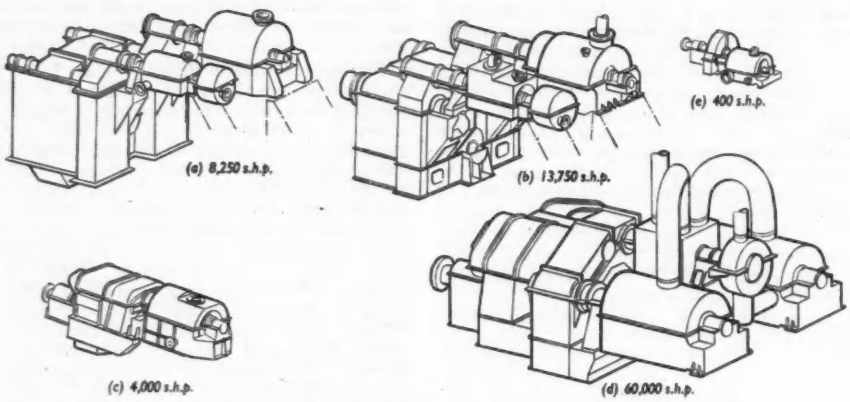


Fig. 5—*Various Turbine Arrangements to Same Scale*

Comparisons of Turbine Arrangements

To enable the external appearance of different turbine configurations to be judged, Fig. 5 has been prepared. The arrangement shown in Fig. 5*a* is being built in large numbers for tank-ship propulsion, and develops a maximum power of 8250 s.h.p. at a speed of 100 r.p.m. of the main shaft. The high-pressure turbine is similar to the 1945 design and the low-pressure turbine to that in Fig. 2. Fig. 5*b* shows a design for 13,750 s.h.p. maximum power, and incorporates a double-casing high-pressure turbine of an earlier type than that shown in Fig. 1. Fig. 5*c* shows an external view of the installation whose turbine section is given in Fig. 3, which has been described in some detail.

The last two arrangements, in Figs. 5*d* and 5*e*, show, respectively, the largest and the smallest installations that have been designed, except as exercises and studies. The larger of the two is designed to develop more than 60,000 s.h.p. on one shaft, and employs a high-pressure turbine, carrying the whole steam flow, and two double-flow low-pressure turbines in parallel. The high-pressure turbine develops approximately half of the total power, and its associated pinion drives two primary wheels and two secondary pinions. Each low-pressure turbine drives a single primary wheel and pinion, thus distributing the load equally between four main pinions. The reduction in weight as compared with that of a normal arrangement, having high-intermediate and low-pressure turbines, was quite marked.

The arrangement shown in Fig. 5*e* was prepared for a twin-screw installation in a lake steamer requiring 400 s.h.p. per shaft. Space was naturally very restricted, and the turbines were arranged to exhaust to a common condenser in the centre of the engine-room. For many reasons, diesel engines would appear to be ideally suited to the propulsion of a vessel such as this, but it was preferred to avoid exhaust noise, which can become appreciable in a pleasure steamer operating in a very quiet land-locked locality.

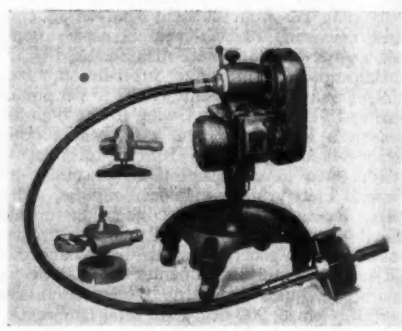
Conclusion

It is hoped that this paper will show that the steam turbine is still a force to be reckoned with among propulsion means for ships, and is likely to continue so for many years. There are indications that in due course the gas turbine will to a large extent supplant the steam turbine, but this will not happen for many years. The flexibility of the steam turbine, and the ease with which it may be adapted for widely different duties, have not yet been exploited to the full, and, in the writer's opinion, the development of steam turbines for marine propulsion will continue actively for a long time.

A Flexible-Drive Machine

A new flexible-drive machine with a range of speeds which adapts it for use with a wide selection of tools is now being made by Flexible Drives (Gilmans), Ltd., 195, High Street, Smethwick, Staffs. This machine is known as the "Flexmaster" and is illustrated below. It consists essentially of a heavy castor-mounted base, with a rigid pillar carrying the motor and driving head, to which the flexible shaft is coupled. The machine is adaptable for suspended, bench or floor mounting as required.

The ¾ h.p. motor drives the head through four-step pulleys and a vee-belt, and changing of the belt position to give different speeds is facilitated by quick-action change and adjustment levers on the head. All handpieces supplied for use with the machine are geared and, according to the purpose for which the handpiece is required, the gearing can be arranged to give a speed increase from 8 to 1 to a reduction of 10 to 1. Thus, with the speed variations available through the four-step main driving pulleys and those in the handpieces, the designed speed range of the machine is from 100 to 24,000 r.p.m. Each handpiece is fitted with a quick-change fitting and there is a similar fitting at the driving end of the flexible shaft.



Flexible-Drive Machine and Some Handpieces

Heat Treatment Practice.—The British Iron and Steel Research Association states that a conference on "Heat Treatment Practice" is to be held on June 15th, 16th and 17th next, at Ashorne Hill, Leamington Spa. It is intended that there shall be papers and discussion on the heat treatment of engineering steels and large forgings and sections, surface treatments, isothermal heat treatment and temperature measurement and control. The conference is being organised by the metallurgy division of B.I.S.R.A., and is expected to provide a meeting ground for engineers and steel-makers affected by these problems. Any persons wishing to attend should apply to Mr. A. M. Sage, B.I.S.R.A., 11, Park Lane, London, W.1.

Industrial and Labour Notes

Iron and Steel Prices

Following the announcement, a few weeks ago, of a general rise of 10 per cent in the pithead price of coal, the Iron and Steel Corporation asked the Minister of Supply to authorise an immediate increase in maximum iron and steel prices. The Corporation pointed out that, as a result of the higher price of coal, the average cost of producing steel would be increased 1 to 1½ per cent.

Last week, the Minister of Supply made an Order authorising increases in the maximum prices of iron and steel by an average of between 1 and 1½ per cent. Some examples of the increases are as follows, the previous basis prices per ton being shown in parentheses :—Foundry and forge pig iron, 10s. (£13 1s. 3d.) ; low-phosphorus pig iron, 6s. 6d. (£16 8s.) ; plates, 12s. 6d. (£29 14s.) ; re-rolled products, 9s. (£31 5s. 6d.) ; cold-rolled strip, 10s. (£44 8s.) ; bright steel bars, 10s. (£42 7s. 3d.) ; galvanised sheets, 13s. 6d. (£50 9s.). The Order, which came into effect on March 14th, is entitled the Iron and Steel Prices (No. 2) Order, 1953.

The Terms of Trade

An article published in the latest issue of *Bulletin for Industry*, which is prepared monthly by the information division of the Treasury, deals with the adverse effect on the United Kingdom's economy by the worsening terms of trade in recent years. It says that, in 1951, the United Kingdom's import prices were, on the average, about four and a half times their 1938 level, while the average of export prices was only three times as high. Had import prices risen no more than export prices in that period the United Kingdom's overall payments deficit in 1951, which was £461 million, would have been replaced by a surplus of about the same amount.

The *Bulletin* points out that, for the United Kingdom, the result of the shift in world prices meant that, between 1938 and 1946, its import prices rose by an average of over 110 per cent, while export prices rose about 95 per cent ; the quantity of exports needed to pay for the same quantity of imports as in 1938 had risen by 8 per cent. In other words, the terms of trade had worsened by 8 per cent—and they went on worsening. By 1947 the terms of trade were 16 per cent worse than before the war, and then came a lull for about two years when they were unchanged. At the end of 1949 they began to worsen again and by 1951 they were about 40 per cent worse than pre-war. Since the middle of 1951, it is stated, there has been some improvement, but last year the terms of trade were still about 30 per cent worse for this country than before the war.

The recent movement of world prices, the article continues, has been in favour of the United Kingdom and the terms of trade have improved ; at the beginning of this year they were only 3 per cent worse than at the outbreak of the Korean war. But, the *Bulletin* adds, there are signs that the improvement may be coming to an end. Since the middle of 1952 export prices have generally been stable or falling while world prices of many raw materials imported by the United Kingdom have recently ceased to fall. There can therefore be no assurance of further assistance from improving terms of trade.

Joint Consultation in Industry

A series of five lectures for directors and senior executives on the general subject of " Recent Researches into the Human Factor " has recently been concluded at the College of Technology, Birmingham. The final lecture was delivered on Thursday of last week, March 12th, by Mr. J. M. Fraser, who dealt, in particular, with joint consultation.

Mr. Fraser said that systematic research had confirmed the conclusions of many practising managers that joint consultation as at present practised in factories had failed to achieve its principal objectives of making all employees feel that they counted as members of the factory community, and of creating in them a feeling of participation in the policies and aims of the factory. The aim which it was hoped to achieve through joint consultation was, nevertheless, of great importance to British industry. It was, Mr. Fraser said, to enhance the community life of the factory by giving all members in it a feeling that they counted as individuals, that they had the opportunity of discussing changes which affected them before such changes took place, that they had an opportunity of understanding the policies and objectives which governed day-to-day activities, and that their personal contribution mattered.

One way of achieving that aim, Mr. Fraser suggested, was to be found through improved managerial and supervisory methods of dealing with people. At every level the manager and supervisor must create relationships with their subordinates out of which mutual confidence, communication of policy, and participation in decision could take place through frank discussion. When those methods of working were effective at each level of authority, a chain of responsible executive control and communication would have been created throughout the organisation. The immediate task of British industry, Mr. Fraser asserted, was to develop among managers, from chief executive to foreman, a deeper understanding of human relations in the factory community and within each managerial team. That, he thought, could only come about through a new policy in the training of managers whereby an appreciation of human relations in the factory community was given equal weight with the technical aspects of the process.

Coal Price Increase

Last week, the Minister of Fuel and Power, Mr. Geoffrey Lloyd, was asked in Parliament, by Mr. Robson Brown, if he would consider making a standstill order holding up the proposed new coal price increases, pending an inquiry. In a written reply, made on March 12th, the Minister said that the recent increase in the pithead price of coal was no more than was necessary to enable the National Coal Board to balance its revenue and expenditure over the year 1953. The Board started the year with a substantial accumulated deficit, and, having regard to its statutory duty to balance revenue and expenditure over good years and bad, it was bound to take steps to avoid the large addition to that deficit which would have been inevitable without an immediate increase in coal prices.

The Minister's reply added that the Government considered that an inquiry at the present time would serve no useful purpose. It would hinder the joint efforts now being made by the National Coal Board and the National Union of Mineworkers to secure that increased production on which the future of the coal industry depended.

World Steel Production

In a survey published in its *Monthly Statistical Bulletin*, the British Iron and Steel Federation gives the estimated total of world steel production in 1952 as 208,000,000 tons, which was only about 1,000,000 tons above the 1951 level. The survey says that the steady growth of world steel production was arrested last year by the eight weeks' strike in the U.S.A., which meant for that country a production loss of about 16,000,000 tons. It is explained, however, that whereas American steel output last year declined by 11 per cent, from 94,000,000 to 83,000,000 long tons, production in the rest of the world rose by 10 per cent, from 113,000,000 to 125,000,000 tons. According to the survey, world steel production is now about 36 per cent above the 1948 level and as much as 72 per cent above the 1937–38 average.

It is explained that, in contrast to last year's setback in the U.S.A., considerable advances were made by the principal steelmakers elsewhere. In Britain there was a sharp recovery from the difficulties of 1951 as new capacity was brought into use and raw material supplies improved. The Schuman group of countries recorded an increase of 4,000,000 tons, or about 10 per cent, of which the greater part was contributed by Germany. Progress was slower last year in France, Belgium and Italy, and, owing to the slackening of export business, Luxembourg registered a slight decline. Among the smaller steel producers of Western Europe, advances were general, these countries showing an aggregate increase of 350,000 tons to an estimated total of 4,800,000 tons. The *Bulletin* goes on to say that the British Commonwealth steel producers—Canada, Australia, India and South Africa—also continued to make headway, their combined output last year being estimated at about 7,700,000 tons, or 9 per cent higher than in 1951.

International Labour Conference Recommendations

A White Paper (Cmd. 8786) has been published setting out the proposed action by the Government on certain of the conventions and recommendations adopted by the International Labour Conference in 1951. One of these recommendations provides that machinery should be set up, by agreement or by laws or regulations, to negotiate collective agreements or to assist the parties to do so. The White Paper says that, subject to certain points, the Government considers this recommendation as generally acceptable, but makes it clear that it does not propose to introduce legislation on any of the matters with which the recommendation deals. While, to a considerable extent, the recommendation embodies principles with which the Government is generally in accord, some of the provisions, the White Paper comments, appear to imply a degree of interference with the independent working of negotiating machinery which would be out of keeping with the traditions of this country.

Another recommendation—which the Government proposes to accept—provides for voluntary conciliation machinery to be available to assist in the prevention and settlement of industrial disputes, " the procedure to be free of charge, expeditious and capable of being set in motion by either party to the dispute or by the voluntary conciliation authority." It is also recommended that the parties in a dispute should be encouraged to refrain from strikes and lockouts whilst the conciliation procedure or arbitration are in progress, and to accept the arbitration award. It is specified, however, that the recommendation does not purport to limit the right to strike.

Britain's Overseas Trade

Provisional figures concerning overseas trade in February, which have been issued by the Board of Trade, give the value of the exports of United Kingdom goods as £194,800,000. It is pointed out that there were only twenty-four working days in February, compared with twenty-seven in January. Taking January and February together, the average monthly value of exports was £206,000,000, compared with a monthly average of £213,000,000 in the final quarter of last year. The value of imports in February was £243,000,000. Re-exports were valued at £9,200,000, so that the excess of imports over total exports was £39,000,000.

The Board of Trade says that exports to North America in February have been valued provisionally at £22,600,000, of which £12,800,000 was for exports to the U.S.A. and £9,800,000 for exports to Canada. This relatively low total, the Board comments, was to be expected in the short month, in addition to which exports to Canada tend to be seasonally low in the early months of the year. For January and February, the average monthly value of exports to North America was £23,800,000, which was below that of the last quarter, but higher than in the earlier quarters of 1952.

Notes and Memoranda

Rail and Road

MR. W. A. NEWMAN.—We have learned with regret of the death, which occurred recently in Montreal, of Mr. William Arthur Newman, chief of motive power and rolling stock on the Canadian Pacific Railway. Mr. Newman, who was sixty-three, joined the mechanical department of the C.P.R. in 1911 and became chief mechanical engineer in 1928. During the war he was engaged in the service of the Canadian Government, first as president and general manager of Federal Aircraft, Ltd., and later as aircraft controller in the Department of Munitions and Supply. After the war, Mr. Newman organised the C.P.R. research department, of which he was manager from 1945 to 1949, when he was appointed chief of motive power and rolling stock.

RAILWAY ELECTRIFICATION SCHEMES.—The Minister of Transport was questioned in Parliament on Monday last as to the railway electrification schemes now being carried out in this country. The Parliamentary Secretary, Mr. Braithwaite, who replied, said that the first stage of the Manchester-Sheffield-Wath project was already in operation and that it was hoped to complete the full scheme in 1955. A further question suggested that, with the greater availability of steel and the greater flexibility of capital investment, it might now be possible to proceed with the electrification of the lines in North London. Mr. Braithwaite stated that that scheme would cost £11,000,000 and the tunnel £5,000,000. He understood from the British Transport Commission that the railway electrification scheme next in priority was the London-Southend line.

Miscellanea

CONVERSION TO OIL.—R. A. Lister and Co., Ltd., announces that the Mark "D" petrol engine of 1½/2 h.p. has been modified to run on tractor vaporising oil and that conversion kit for existing engines is available. The changeover to vaporising oil is estimated to effect a saving of up to two-thirds in fuel costs.

SOLDERING FLUID.—A new soldering fluid has been introduced by Fluxite, Ltd., of 63, Bermondsey Road, London, S.E.1, which is intended to give improved results when dealing with long seams or large surfaces. The fluid incorporates a special wetting agent which ensures that its application is effective whether applied by dipping or by brush.

GAS TURBINE PUMPING UNIT.—The Kuwait Oil Company, Ltd., is to install a gas-turbine-driven pumping unit in its latest oil gathering centre. Ruston and Hornsby, Ltd., has built the gas turbine which develops 1000 h.p. and will be operated on gas from the oilfields. The performance of the turbine will be observed by the oil company's engineers and they will assess its suitability for use in pipeline pumping stations.

WORK STUDY GLOSSARY.—The Institute of Economic Engineering has published a Work Study Glossary, which has been prepared by a committee, set up by the council, under the chairmanship of Mr. H. E. Kearsey. The terms included in the glossary are arranged under the three general headings of method study, motion study and work measurement. The aim of the committee has been to group related terms alphabetically under these sectional headings. The price of the glossary is 2s. 6d. Copies may be obtained from the Institute of Economic Engineering, 28, Victoria Street, London, S.W.1.

NEW FACTORY AT KIRKBY, LIVERPOOL.—Work has been started on the construction of a new factory at Kirkby, Liverpool, for Tubewrights, Ltd. The factory will be used for the production of standard tubular structures and components, which are at present made in the Newport, Monmouthshire, factory of the parent company, Stewarts and Lloyds, Ltd. The new factory is to be a single-storey building about 360ft square. The tubular steel frame will have a girder span of 120ft. The architects for the factory are Sir Alfred Shennan and Partners, the main contractor being Taylor Woodrow Construction, Ltd.

UNIT FOR DRILLING POLYGON SHAPED HOLES.—A new design of "Polygon" box unit introduced by Thos. Chatwin and Co., of Birmingham, can be used on standard drilling machines for boring polygon holes. In use this unit is fitted on a spindle which rotates it at about 200 r.p.m. and preferably feeds at about 0·001in per revolution by automatic traverse. The tool used for turning and boring is easily ground and work of any shape or diameter can be accommodated. The shapes produced are relative to the fixture, so that any number of holes can be produced around a periphery in correct relationship to the centre.

A V.H.F. POWER TETRODE.—A hard-glass power tetrode valve, "QY3–125," is being made by Mullard, Ltd., for use as an oscillator or r.f. amplifier in compact communications and allied electronic equipments operating in the v.h.f. range. It is constructed in hard-glass on the "B5F" base. The main characteristics of the valve are: filament voltage, 5·0V; filament current, 6·5A; anode voltage (maximum), 3000V; anode dissipation (maximum), 125W; output, 375W up to 120 Mc/s; cathode current (maximum), 270mA frequency (maximum), 120 Mc/s at full ratings: frequency (maximum), 200 Mc/s at reduced ratings.

EUROPEAN COAL AND STEEL PRODUCTION.—Information published by the statistical department of the High Authority shows that during the first nine weeks of 1953 the collieries of the European Coal and Steel Community produced approximately 42,810,000 tons of hard coal, as against 42,270,000 tons during the same period of last year. It is also stated that the European Coal and Steel Community produced during February 2,700,000 tons of pig iron and 3,300,000 tons of crude steel. During January and February 7,000,000 tons of crude steel were produced, compared with 6,800,000 tons during the same two months of 1952.

RESIDENTIAL TRAINING FOR FOREMEN.—The Institute of Industrial Supervisors says that it has now arranged four residential training course programmes for foremen and supervisors. They deal with the practice of supervisory management; human relations, communication and discipline for supervisory management; work study for supervisory management; and industrial relations and industrial law. For the current year the Institute has planned twenty residential courses to be held at Dillington House, near Taunton, at Ashorne Hill, Leamington Spa, and at Missenden Abbey, Bucks. At the request of companies in Glasgow and the West of Scotland, the Institute is organising a residential course at the Allan Water Hotel, Bridge of Allan, on the subject of "The Practice of Supervisory Management." Full details of all the courses are available from the Institute of Industrial Supervisors, 47, Temple Row, Birmingham, 2.

IRON AND STEEL INSTITUTE AWARDS.—The council of the Iron and Steel Institute has awarded the Bessemer Medal for 1953 to Mr. Richard Mather, past-president, for his distinguished services to the Institute and to the iron and steel industry. The Sir Robert Hadfield Medal has been awarded to Mr. W. E. Bardgett in recognition of his contribution to the development of alloy steels, with particular reference to steels for service at elevated temperatures. Dr. E. T. Turkdogan is to receive an Andrew Carnegie Silver Medal for his research on slag-metal reactions reported in papers written in collaboration with Dr. W. R. Maddocks. Dr. S. A. Burke and Mr. G. A. Sparham have been awarded the Ablett Prize for 1952 for their paper entitled "Automatic Control of Coal Feed in Steelworks Gas Producers." The awards will be presented during the annual general meeting of the Institute on April 30th.

BREADALBANE TRANSMISSION LINES.—The Secretary of State for Scotland has confirmed a scheme prepared by the North of Scotland Hydro-Electric Board for transmission lines associated with the Lawers and Breadalbane projects at a cost of £865,000. The works in the scheme include the erection of overhead transmission lines in the Parishes of Killin, Kenmore, Balquhidder, Comrie and Fortingall to link the seven generating stations of the Breadalbane project and one generating station of the Lawers project to the existing transmission lines at Killin and Luib. Transforming stations will be built at these generating stations and at Killin. Some of the proposed transmission lines may be used initially to provide power for the construction of the works proposed under the Board's Breadalbane project which is at present before Parliament. The Amenity and Fisheries Committees have made no observations on the scheme and all the objections lodged against the scheme have been withdrawn. A White Paper on the scheme has been published and is available (price 2d.) from H.M. Stationery Office, 13A, Castle Street, Edinburgh.

EFFICIENT MATERIALS HANDLING.—A lecture on "Materials Handling" was delivered to the Gravesend and District Engineering Society on Tuesday last by Mr. L. Landon Goodman, of the British Electrical Development Association. Mr. Goodman said that little attention had been paid up to the present to handling and this applied not only to manufacturing but to all situations where material was moved and stored. Recently more attention had been given to the proper consideration of the various principles involved in the new technology and the results that had been achieved in individual cases by the correct application of these principles had been truly outstanding. An increase of 20 per cent in productivity with no increase in the equipment required was quite commonplace. In the course of his lecture, Mr. Goodman outlined the various kinds of equipment available for materials handling and processing, including cranes, conveyors, runways, battery-driven trucks and electronic control and regulation. He said that materials handling and materials processing were closely linked and should always be considered together.

SUGAR BEET DRILL COMPETITION.—In our issue of August 22, 1952, some preliminary details were given of a competition to encourage the production of precision root drills in this country. It has now been decided that the competition is to take place on a Norfolk farm next month. The competition will be in two classes: for tractor-drawn machines in commercial production which sow not less than four rows at once; for tractor-drawn prototype machines sowing four rows or fewer at once. Nine entries have been made in the first class and twelve in the second. It is expected that a public demonstration of most of the machines will be held a few days after the competition. In addition, small plots will be drilled ahead of the competition in order that the emergence achieved may be inspected at the time of the public demonstration. The object of the competition is to encourage the manufacture in this country of a sugar beet precision drill (preferably a machine capable of being adaptable for other root crops), as an essential first step towards greater economy in thinning root crops. The organisers of the competition—the Sugar Beet Research and Education Committee—define a precision drill as one that is capable of depositing seed singly and separately along the row at specified distances and covering them in the same operation. Each machine will be subjected to three main tests, during each of which it will be required to sow two rounds in each of two selected fields.

Personal and Business

MR. F. H. HARRIS has been appointed group production adviser of Associated British Engineering, Ltd.

MR. L. W. D. SHARP, A.M.I.E.E., has been appointed chief engineer in the components division of The Plessey Company, Ltd., Ilford, Essex.

ALBION MOTORS, Ltd., announces that its Bristol depot is now situated in new premises at Whitehouse Street, Bedminster, Bristol, 3.

MR. J. F. BICKERTON, M.I.C.E., assistant district engineer, Paddington, British Railways (Western Region), has been appointed district engineer, Cardiff.

COAST LINES, Ltd., announces that Lord Teynham, D.S.O., D.S.C., a director of Grayson Rollo and Glover Docks, Ltd., and Mr. Gordon Beazley have joined the board of the company.

THE WHARTON CRANE AND HOIST COMPANY, Ltd., Reddish, states that it is now represented throughout Scotland by Fisher, Baxter and Co., Ltd., 140, West George Street, Glasgow, C.2.

E. K. COLE, Ltd., has registered Ekco Electronics, Ltd., as a wholly-owned subsidiary to be responsible for the marketing of its electronic equipment. The new company's registered office is at Ekco Works, Southend-on-Sea.

THE BRITISH ELECTRICITY AUTHORITY announces the following appointments: Dr. F. H. Last, technical engineer (electrical), Eastern Generation Division, and Mr. E. C. Scott, A.M.I.E.E., system operation engineer, North Eastern Division.

MR. W. L. HENDERSON, A.M.I.E.E., is resigning his position as assistant secretary of the Engineers' Guild, in order to take up a post in industry. The general council of the Guild has appointed Mr. J. G. OTT, M.A., to succeed Mr. Henderson.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces the formation of a subsidiary in Australia under the name of British Insulated Callender's Cables (Australia) Pty., Ltd. Sir T. Malcolm Ritchie is the chairman of the new company, the registered office of which is at 84–88, William Street, Melbourne, C.1.

BLACKBURN AND GENERAL AIRCRAFT, Ltd., Brough, East Yorks, announces the following appointments in its engine division: Mr. F. R. Bell, chief designer (engines), and Mr. W. B. Mathison, assistant chief designer; Group Captain H. J. Wilson, sales manager (engines), and Mr. J. J. Gadd, commercial sales manager (engines); Mr. E. Mitchell, works manager (engines).

THE HAMWORTHY ENGINEERING COMPANY, Ltd., Poole, states that Mr. W. Kemp has been appointed deputy chairman and that Mr. A. F. Ferguson has succeeded him as managing director. Mr. James Hendry has been appointed sales director and Mr. R. G. Peach technical director. Mr. Ingram Spencer, the chairman of the company, is at present on business in Australia.

Launches and Trial Trips

DUNNET HEAD, bulk cargo carrier; built by Henry Robb, Ltd., for A. F. Henry and MacGregor, Ltd.; length between perpendiculars 180ft, breadth moulded 31ft, depth moulded to upper deck 15ft, deadweight 900 tons on 13ft 3in mean draught, speed 10 knots; British Polar diesel engine, four cylinders, 640 b.h.p. at 250 r.p.m. Launch, March 17th.

POLARTANK, oil tanker; built by Barclay, Curle and Co., Ltd., for Melsom and Melsom, Norway; length 566ft, breadth 72ft 6in, depth 40ft 6in, deadweight 19,000 tons; twenty-seven cargo oil tanks, two pump-rooms, four cargo oil pumps, deck sprinkling and steam smothering arrangements; Barclay, Curle-Doxford oil engine, six cylinders 750mm diameter by 2500mm combined stroke; two cylindrical multi-tubular boilers. Trial, March 11th.

LA BOURDONNAIS, passenger liner; built by Chantiers Navals de Lorient for the Cie des Messageries Maritimes; length between perpendiculars 459ft 4in, breadth moulded 63ft 4in, depth moulded to "C" deck 38ft 5in, load draught 24ft 3in, load displacement 13,700 tons; deadweight 6100 tons; speed 17 knots; two ten-cylinder Penhoët-Burmeister and Wain two-stroke, single-acting, diesel engines, cylinders 620mm diameter by 1150mm stroke, total b.h.p. 12,000. Trial, February.

QUEENSBURY, cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for the Alexander Shipping Company, Ltd.; length between perpendiculars 430ft, breadth moulded 59ft 9in, depth moulded to shelter deck 39ft 3in, draught loaded 26ft 9in, deadweight 10,500 tons; two Gray-Polar M.T. oil engines, each of six cylinders, 500mm diameter by 700mm stroke, driving single shaft through hydraulic couplings and single-reduction gear, 4315 s.h.p. at 110 r.p.m. Launch, March 16th.

GENERAL MANGIN, passenger liner; built by Chantier et Ateliers de Saint-Nazaire Penhoët for the Compagnie de Navigation Fraissinet; length between perpendiculars 492ft 2in, breadth moulded 64ft 10in, depth moulded to upper deck 43ft 3in, load draught 22ft 9in, load displacement 14,068 tons, deadweight 5400 tons; service speed 16 knots; three complete decks, nine water-tight compartments, five holds, total number of passengers 942, including 132 first-class and 125 second-class; two 405kW and one 305kW diesel-driven generators; two Burmeister and Wain two-stroke, single-acting, diesel engines, 8300 b.h.p. at 137 r.p.m. Trial, March.

British Patent Specifications

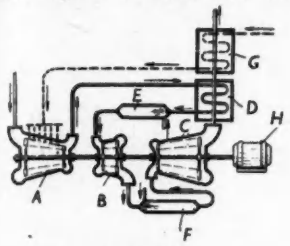
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 1s. 6d. each.

GAS TURBINES

687,480. February 24, 1949.—GAS TURBINE PLANTS, Societe Rateau, 40, Rue du Colisée, Paris, and René Anxionnaz, 8, Rue Nicolas Chuquet, Paris.

The drawing shows a gas turbine plant in which the steam for producing a composite fluid of gas and steam is produced by mixing it with air in the compressor, by injecting water between the blade-wheels. The quantity injected is that necessary for saturating the compressed air and an important part of the work of compression instead of being lost in coolers is used for obtaining the steam, which, with the air, forms the composite fluid used in one or more



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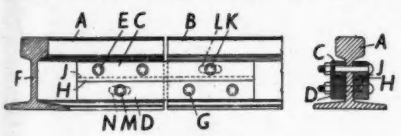
turbines. The compressor *A* is driven by gas turbines *B* and *C*. The air leaving the compressor is heated by the exhaust gas in the exchanger *D*, after which it passes to the combustion chamber *E*, where it is raised to a suitable temperature by the burner. It is then partially expanded in the gas turbine *B*, reheated in the second combustion chamber *F*, and then expanded down to atmospheric pressure in the gas turbine *C*. The exhaust gases enter the two heat exchangers *D* and *G* before they are discharged to the atmosphere. In the exchanger *G* the water to be injected into the compressor *A* is heated by the exhaust gases flowing from the exchanger *D*. The available power, the difference between that provided by the two gas turbines and that taken by the air compressor drives the electric generator *H*. The specification also gives detailed drawings of various methods of injecting the water into the compressor. —*February* 18, 1953.

RAILWAY ENGINEERING

687,648. November 13, 1951.—JOINTS OF RAILS OF RAILWAY PERMANENT WAY, Vivian Edward Depenning, an Indian subject, of H. V. Williams and Co., of 29, Waterloo Street, Calcutta—1, West Bengal, India.

The drawings show the ends of rails *A* and *B* which are to be joined and an end section. A fish-plate, comprising two bars *C* and *D* is provided. The bar *C* is fixed by bolts and nuts *E* to the web *F* of the rail *A* and the bar *D* is similarly fixed by bolts and nuts *G* to the rail *B*. Similar bars are also provided on the other side of the rail web. By means



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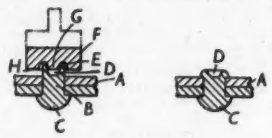
of a lug *H* formed on bar *D* and a corresponding slot *J* in the bar *C* the two bars slidably engage each other in the longitudinal direction of the rails. The bar *C* is fixed by a bolt and nut *K* through an elongated hole *L* cut in the web of the rail *B* and similarly bar *D* is also fixed by a bolt and nut *M* through an elongated hole *N* cut in the web of the rail *A*, and this bolt is also passed through a corresponding hole in the corresponding bar on the other side of the web. Modified designs including bars with slots and lugs cut in the upper and lower edges and also "T"-shaped fish-plates are shown in the specification.—*February* 18, 1953.

METALLURGY

687,574. August 15, 1949.—ALUMINIUM RIVETS, The Minister of Supply, Shell Mex House, Strand, London, W.C.2. (*Inventor: John Gwynne Whitman.*)

The invention relates to the cold closing of rivets of aluminium or aluminium alloy by pressing or by the use of a pneumatic hammer and is mainly, though not exclusively, applicable to rivets of ¼in diameter or over. The left-hand drawing shows a plate *A* drilled for the insertion of an aluminium alloy rivet *B* with, at one end, the head *C* and at the other end a conical depression *D* having upstanding walls *E*. The rivet set *F* is so shaped as to have



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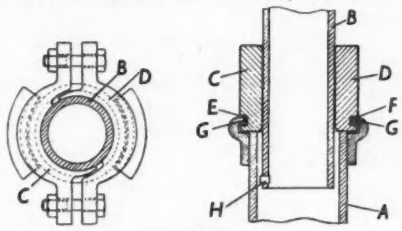
a central spigot portion *G* to fit into the depression at the end of the rivet and also a surrounding rim *H*, which tends to shape the external periphery of the rivet head to be formed. The spigot portion *G* and surrounding rim *H* define between them an annular groove, the width of which is greater than the thickness of the wall *E* surrounding the conical depression. Thus, the rim *H* does not come into contact with the metal of the rivet until the later stages of the closing operation. Throughout the earlier and main portion of the closing operation the metal of the rivet end is free to be deformed radially inwards and outwards without constraint, and the metal of the rivet shank to deform outwards to fill the rivet hole. The rivets may be made with hollows at both ends.—*February* 18, 1953.

MINING ENGINEERING

687,681. December 15, 1950.—PIT PROPS, Essen-Bottroper Handelgesellschaft mit Beschrankter Haftung, trading as Hermann Schwartz K.G., Wattenscheid, Germany.

Referring to the drawings, a lower outer cylindrical tubular prop part *A* accommodates a sliding inner prop *B*. A clamping collar which grips the upper part and holds it by friction is mounted so that it rests on the upper edge of the lower prop. The collar comprises two similar halves *C* and *D* with



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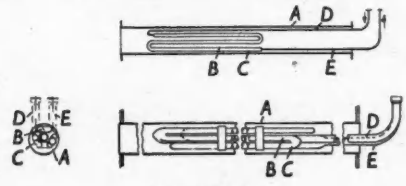
annular grooves *E* and *F* in which collar retaining members engage by their claws *G*. The retaining members are formed with lower curved portions, which lie against the outer surface of the lower part of the prop. The collar is tightened by forcing the ends together by bolts as shown. The upper prop part *B* has on its lower end a stop *H* which engages the lower edge of the clamping collar when the upper prop is drawn out and prevents complete disengagement of the two parts. The specification also shows a construction in which adjacent ends of the collar halves are hinged together.—*February* 18, 1953.

STEAM GENERATORS

687,798. October 19, 1950.—SMOKE-TUBE SUPERHEATERS, Schmidt'sche Heissdampf-Gesellschaft mit Beschrankter Haftung, 273, Wilhelmshöher Allee, Kassel-Wilhelmshöhe, Germany.

This invention relates to a smoke tube steam superheater element of great length and large internal diameter for large steam locomotives. Referring to the drawing it will be seen in the upper view that the



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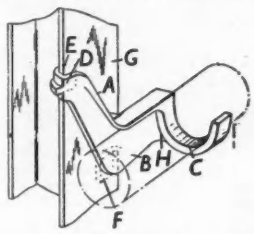
superheater element is accommodated in a smoke tube *A* so that its most effective heating surface extends forwards approximately from the middle of the smoke tube towards the firebox. This part of the heating surface consists of two tubes *B* and *C*, each comprising three straight lengths, the two tubes being connected in parallel. Connected to the two ends of both of these tubes are single pipes *D* and *E* for saturated steam coming from the boiler and superheated steam fed to a steam box respectively. In the upper view the steam supply pipe *D* is attached to the ends of the tubes *B* and *C* lying next to the firebox, so that the steam in each tube must flow twice away from the firebox and once towards the firebox. The tubes *B* and *C*, as shown in the lower view, are arranged in such a manner that the longitudinal axes of the individual tube lengths are disposed at the corners of a hexagon, which is most favourable for the accommodation of the tubes in the cross-sectional surface available in the smoke tubes. The supply and return steam pipes *D* and *E* through the bifurcation pieces merge into the tubes *B* and *C*. The total internal cross-section of the two parallel connected tubes is arranged to be approximately equal to the common internal cross-section of each of the supply and return steam pipes *D* and *E*. The steam is distributed from the supply pipe *D* to the two tubes *B* and *C* by way of a bifurcation piece, flows through tubes and leaves the superheater through the pipe *E*. A modified condenser is also shown in the specification.—*February* 18, 1953.

STRUCTURAL ENGINEERING

688,047. May 2, 1950.—A CLIP FOR STRUCTURAL MEMBERS, Follsain-Wycliffe Foundries, Ltd., Lutterworth, Leicestershire.

The clip has a body with its main section *A* in the form of a flat, generally rectangular, bar, which, at its lower end, has an extension *B* carrying the pole or tube mounting bracket *C*. At its upper end *D* the bar is offset a short distance and, standing



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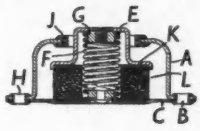
proud of the bar at this part is a bent-over lug *E*. Towards its lower end the bar is furnished with a similar bent-over lug *F*. The two lugs *E* and *F* each form, with the adjacent underlying portion of the clip body, a jaw of open-ended, deep channel section which is engaged with an edge of the flange *G* of the "I"-girder. The extension *B* at the bottom of the bar is reinforced by ribs and its outer end is cranked at *H* to carry the mounting bracket *C* for the pipe or tube to be supported.—*February* 25, 1953.

MISCELLANEOUS

687,467. October 19, 1951.—VIBRATION ISOLATOR, The Barry Corporation, 700, Pleasant Street, Watertown, Massachusetts, U.S.A.

This invention relates to flexible mountings, known as vibration isolators, which are used in aircraft for mounting delicate equipment. It will be seen from the drawing that the isolator consists of a cylindrical housing *A* with a lower, square-edged peripheral flange *B*, to which a bottom plate *C* is held by eyelets. The upper wall of the housing has an opening through which one end of a load-receiving element in the form of an inverted cup *E* is inserted. The main load-transmitting spring *F* extends between the bottom plate and the



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cup. It is centred in the cup by a tapped boss *G* swaged to the cup, and is located at its bottom end by another boss riveted to the bottom plate. The load to be mounted is attached to the isolator by a bolt which threads into the tapped boss and the isolator is attached to the aircraft structure by means of bolts through the eyelets *H*. A rubber snubber *J* is provided around the opening in the upper wall of the housing to cushion extreme motion of the mounted equipment. The inverted cup *E* is provided with a peripheral flange *K* on its lower edge. A tubular damper *L* encircles the lower part of the spring and is confined between the peripheral flange *K* and the bottom plate *C*. The damper is compressed by downward vibratory movement and extends when the vibrating body moves upwards. It is formed of interlocked wires, preferably of corrosion resistant wire, the interlocked strands of which rub on one another as compression and extension of the damper occurs. These wires also tend to bulge inwards during compression and so tend to rub on the coils of the spring. The friction involved in this rubbing takes energy from the vibrating system and imposes a restriction on the amplitude of the vibration which may occur.—*February* 11, 1953.

Technical Reports

The Electro-Chemistry of Non-Aqueous Solutions. By I. G. Roe, Ph.D. The British Electrical and Allied Industries Research Association (Ref. L/T278). Price 15s., postage 4d—This abridged version of a thesis for a Ph.D. degree discusses the anomalous behaviour of certain weakly conducting organic solutions when subjected to an ionising potential over a period of time. Various systems of picric acid in nitriles and ketones were used in the investigation and observations were made of the variation of equivalent conductance with concentration and with time.

The Bond Strength of Galvanised Steel in Concrete. By G. Mole, Ph.D., F.Inst.P. The British Electrical and Allied Industries Research Association (Ref. O/T7). Price 12s., postage 3d.—Information is required on the bond strength of angle-section galvanised steel reinforcing in concrete in order to facilitate the design of footings for steel-lattice transmission line towers. Tests have been made to determine the relative influence of: (1) round or angle section, (2) smooth or rough surface, (3) plain or galvanised steel. The results are sufficiently consistent to allow significant conclusions to be deduced. These show that there are no large differences between the bond strengths of round and angle reinforcing, and the bond strength of galvanised reinforcing is nowhere less than two-thirds that of plain steel.

The Effect of Inductance on the Fine Transfer between Platinum Contacts. By J. Warham, B.A. The British Electrical and Allied Industries Research Association (Ref. U/T125). Price 12s., postage 4d.—Recent experimental work of J. J. Lander with an ultra-high speed oscillograph showed the existence of a transient arc of duration less than 0·1 microsecond between contacts breaking a circuit which was supposedly non-arcing. These results gave support to the suggestion that inductive energy stored in a circuit at break might account for fine transfer which had previously been considered independent of arcing. The present investigation describes the effect on fine transfer of the circuit self-inductance in the range 0·05 to 10 microhenries. The results show that for platinum contacts at 6V and 1·75A and 0·95A there is a residual transfer independent of inductance, but transfer is dependent on inductance when this is greater than about 0·3 microhenries.

Flameproof Enclosure of Electrical Apparatus: Gaseous Explosions in Communicating Compartments; the Influence of Turbulence and Pressure Piling. By By J. A. B. Horsley, O.B.E., M.I.E.E. (Ministry of Fuel and Power). The British Electrical and Allied Industries Research Association (Ref. G/T265). Price 6s., postage 3d.—In this review investigations that were carried out by the Safety in Mines Research Board, as recorded in S.M.R.B. papers Nos. 10 and 49, published by H.M. Stationery Office in 1925 and 1929, are summarised. The report has been prepared to present the scientific evidence upon which the routine testing of electric motors, as to flameproof enclosure, was based when the Mines Department of H.M. Board of Trade (since absorbed in the Ministry of Fuel and Power), took over that duty from the Mining Department of the University of Sheffield in 1931.

In brief, it was considered that the scientific evidence justified routine testing with the motor at rest, artificial means being used to simulate the effects of turbulence such as might be expected to result with the motor when running. The artifice used has been to keep the inflammable gas in circulation through the motor casing, by means of a fan, and to ignite the inflowing gas in a pocket outside the point of entry.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Tues., March 24th.—YORK BRANCH: Creamery Restaurant, Pavement, York, "Installation and Maintenance of Electric Motors," R. Spence, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., March 24th.—W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "The Principles of Electronic Computing Machines," B. V. Bowden, 7.15 p.m.

ENGINEERS' GUILD

Tues., March 24th.—W. MIDLANDS BRANCH: Imperial Hotel, Temple Street, Birmingham, Film, "Inland Waterways," introduced by F. E. B. Clayton, 6.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., March 23rd.—LEICESTER CENTRE: E. Midlands Electricity Board, Charles Street, Leicester, "Display Lighting for the Coronation," 6.30 p.m.

Tues., March 24th.—LIVERPOOL CENTRE: Electricity Board's Service Centre, Whitechapel, Liverpool, "Lighting in Shipyards," J. S. McCulloch, 6 p.m.

Wed., March 25th.—INFORMAL MEETING: Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, Short Papers by Student Members, 6 p.m.

Thurs., March 26th.—BRADFORD GROUP: Yorkshire Electricity Board, 45-53, Sunbridge Road, Bradford, Fluorescent Forum, Questions and Answers, 7.30 p.m.

Mon., March 30th.—LEEDS CENTRE: Lighting Service Bureau, 24, Aire Street, Leeds, 1, Annual General Meeting, followed by "Lighting and Vision as Age Advances," H. C. Weston, 6.15 p.m.

Tues., March 31st.—CARDIFF CENTRE: S. Wales Electricity Board, Cardiff, "Development of Lamps Other than Tungsten," E. J. G. Beeson, 5.45 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., March 25th.—LONDON BRANCH: Waldorf Hotel, Aldwych, London, W.C.2, Paper and Film on "Match Plates," D. H. Potts, 7.30 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

Fri., March 27th.—Engineers' Club, Albert Square, Manchester, "Methods Time Measurement," B. Davis, 7 p.m.

INSTITUTE OF FUEL

Tues., March 24th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Experience with Spreader Stokers," T. H. Lindsay and P. Pilkington, 5 p.m.

INSTITUTE OF MARINE ENGINEERS

To-day, March 20th.—EDUCATION GROUP: 85 Minories, London, E.C.3, Annual General Meeting, followed by a Discussion on "The Alternative Training Scheme and its Possible Effects on the Institute's Requirements for Membership," opened by Stewart Hogg, 5.30 p.m.

Tues., March 24th.—85, Minories, London, E.C.3, Annual General Meeting, 5.30 p.m.

Thurs., March 26th.—Technical College, Acton, "Construction of Steam Turbines," J. Brown, 7.15 p.m.

Fri., March 27th.—Conway Street Secondary School, Birkenhead, "Photo-Elasticity," J. Ward, 7 p.m.

INSTITUTE OF NAVIGATION

To-day, March 20th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Dead Reckoning in Space," Samuel Herrick, 5 p.m.

INSTITUTE OF PETROLEUM

Tues., March 24th.—26, Portland Place, London, W.1, "A Symposium on the Examination of Used Lubricating Oils," H. C. Evans, J. B. Matthews, J. Hughes, J. H. T. Brook, and R. P. Taylor, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., March 24th.—N.E. OF ENGLAND GROUP: County Hotel, Newcastle upon Tyne, Selection of Short Papers by Members 7 p.m.

INSTITUTE OF WELDING

Thurs., March 26th.—MEDWAY SECTION: Sun Hotel, Chatham, Annual General Meeting, 7.15 p.m.

Fri., March 27th.—E. OF SCOTLAND BRANCH: 25, Charlotte Square, Edinburgh, "Application of Jigs and Fixtures for Steel Fabrication," 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., March 24th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Hydraulics in Modern Tractors," H. E. Ashfield, 2.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., March 24th.—PUBLIC HEALTH MEETING: Great George Street, Westminster, London, S.W.1, "Controlling Factors in the Choice of Sewage Treatment Processes for Sewage Disposal," W. Fillingham Brown, 5.30 p.m.

Thurs., March 26th.—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "The Trend of Development in the Design and Equipment of Underground Railways," D. H. Coombs and G. J. Willson, 5.30 p.m.——N.W. ASSOCIATION: JOINT MEETING WITH THE INSTITUTION OF STRUCTURAL ENGINEERS: Engineers' Club, Albert Square, Manchester, "Some Recent Foundation Research and its Application to Design," G. G. Meyerhof, 6.30 p.m.

Fri., March 27th.—YORKSHIRE ASSOCIATION: Royal Victoria Station Hotel, Sheffield, "The Lee-McCall System of Prestressed Concrete," M. S. Wright, "Some Applications of Soil Mechanics," J. Holt, 7 p.m.

Tues., March 31st.—ROAD MEETING: Great George Street, Westminster, London, S.W.1, "Factors Affecting the Riding Qualities of Machine-Laid Concrete Roads," R. H. H. Kirkham, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., March 23rd.—RADIO SECTION: Savoy Place, London, W.C.2, Debate, "That Broadcasting Hours Should be Drastically Curtailed," 5.30 p.m.

Wed., March 25th.—SUPPLY AND MEASUREMENTS SECTIONS: Savoy Place, London, W.C.2, "Transformer-Analogue Network Analysers," M. W. Humphrey Davies and G. R. Slemon, 5.30 p.m.——S.E. SCOTLAND SUB-CENTRE: Heriot-Watt College, Edinburgh, "Application of Transductors as Relays to Protective Gear," R. K. Edgley and F. L. Hamilton, 7 p.m.

Thurs., March 26th.—EXTRA MEETING: Savoy Place, London, W.C.2, "Studies of Telephone Traffic with the Aid of a Machine," S. W. Broadhurst and A. T. Harmston, 5.30 p.m.

Fri., March 27th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Special Features of Courses in Electrical Engineering in the Royal Navy," opened by L. S. Bennett, 6 p.m.

Mon., March 30th.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Use and Abuse of Research," opened by S. Whitehead, 5.30 p.m.——S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on "Electric Heating," opened by E. H. Cox, 6 p.m.

Tues., March 31st.—N. MIDLAND CENTRE: Chemistry Lecture Theatre, The University, Leeds, "275kV Developments on the British Grid System," D. P. Sayers, J. S. Forrest and F. J. Lane, 6.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Thurs., March 26th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "A Rational System of Nomenclature in Ferrous Metallography," P. Cranston, 7.30 p.m.

Tues., March 31st.—S.W. BRANCH: Grand Hotel, Broad Street, Bristol, "Photoelastic Methods of Stress Analysis," H. D. Haddon, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., March 24th.—39, Elmbank Crescent, Glasgow, "Fire Protection of Buildings," N. Strother Smith, 7.15 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 20th.—GENERAL MEETING ARRANGED IN CONJUNCTION WITH THE APPLIED MECHANICS GROUP: Storey's Gate, St. James's Park, London, S.W.1, "A Room Temperature Photoelastic Technique for Three-Dimensional Problems," J. H. Lamble and Salah E. A. Bayoumi; "The Use of Celuloid Models in Structural Analysis," J. D. C. Crisp, 5.30 p.m.——WESTERN BRANCH: Royal Naval Engineering College, Manadon, Plymouth, "Welding in Marine Engineering," H. N. Pemberton, 6 p.m.

Sat., March 21st.—YORKSHIRE BRANCH, GRADUATES' SECTION: The University, Leeds, "Hydraulic Plant Reorganisation," W. P. Polling, 2.30 p.m.

Tues., March 24th.—EASTERN BRANCH: Great White Horse Hotel, Ipswich, "Rocket Propulsion," A. D. Baxter, 7.30 p.m.——E. MIDLANDS BRANCH: JOINT MEETING WITH THE INSTITUTION OF ELECTRICAL ENGINEERS: Gas Showrooms, Upper Parliament Street, Nottingham, "Some Current Problems in the Field of Technical Education," D. S. Anderson, 7.30 p.m.——BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Problems Arising from the Wider Use of Small Diesel Engines," J. H. Pitchford, 6.45 p.m.

Wed., March 25th.—SOUTHERN BRANCH: JOINT MEETING WITH THE INSTITUTION OF ELECTRICAL ENGINEERS: Chamber of Commerce, Commercial Road, Portsmouth, "Some Aspects of Generating Station Construction," C. W. A. Price, 6.30 p.m.——SOUTHERN BRANCH, GRADUATES' SECTION: Municipal College, Bournemouth, Technical Film Show, "Basic Principles of Lubrication" and "Britain Awakes," 7 p.m.

Thurs., March 26th.—SCOTTISH BRANCH, GRADUATES' SECTION: Room 24, Royal Technical College, Glasgow, "Characteristics and Selection of Air Compressors," William Scott, 7.30 p.m.——WESTERN BRANCH, GRADUATES' SECTION: Visit to Hoseagood Industries, Ltd., Avonmouth, 6.30 p.m.

Fri., March 27th.—Storey's Gate, St. James's Park, London, S.W.1, Annual General Meeting, Annual Report, including Statement of Accounts, 5.30 p.m.

Sat., March 28th.—YORKSHIRE BRANCH, GRADUATES' SECTION: College of Technology, Pond Street, Sheffield, "The Use of Oil Injection Fitting in Steelworks Maintenance," J. A. Abrahams, 2.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., March 31st.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Alternatives to the Conventional P.C.L.C. Telecommunications Cable," J. Gerrard, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., March 23rd.—MANCHESTER SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Planning and Production Methods Used in the Construction of the de Havilland 'Comet,'" H. Povey, 7.15 p.m.

Wed., March 25th.—SHREWSBURY SECTION: Technical College, Shrewsbury, "Productivity and the Machine Tool," N. Stubbs, 7.30 p.m.——WESTERN SECTION: Grand Hotel, Bristol, 1, Annual General Meeting and Films, "Yorkshire in the Making," "The Yorkshire Way," "Yorkshire on Special Service," 7.15 p.m.

Thurs., March 26th.—CORNWALL SECTION: School of Mines, Camborne, "A Broader Conception of Productivity and its Measurement," F. G. S. English, 7.15 p.m.——LONDON SECTION: Royal Empire Society, Northumberland Avenue, London, W.C.2, "Industrial Architecture," H. V. Lobb, 7 p.m.——S. WALES SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, "Industrial Economics," C. T. Trager, 6.45 p.m.

Tues., March 31st.—DUNDEE SECTION: Works Visit to North of Scotland Hydro-Electric Board, Power Station, Carolina Port, Dundee.——LUTON SECTION: Small Assembly Room, Town Hall, Luton, "Some Visits to American Factories Engaged in Jobbing Engineering," G. P. E. Howard, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., March 26th.—11, Upper Belgrave Street, London, S.W.1, "A Simple Theory of Suspension Bridges," A. G. Pugsley, 6 p.m.——LANCASHIRE AND CHESHIRE BRANCH: JOINT MEETING WITH THE INSTITUTION OF CIVIL ENGINEERS: Engineers' Club, Albert Square, Manchester, "Some Recent Foundation Research and its Application to Design," G. G. Meyerhof, 6.30 p.m.

Tues., March 31st.—NORTHERN IRELAND BRANCH: College of Technology, Belfast, Annual General Meeting 6.45 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 20th.—ORDINARY MEETING: Townsend House, Greycoat Place, London, S.W.1, "The Aether—an Engineering Conception," J. Heywood, 7 p.m.

Fri., March 27th.—INFORMAL MEETING: Townsend House, Greycoat Place, London, S.W.1, "Copying Lathes," K. J. Downes, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., March 27th.—Engineers' Club Albert Square Manchester, Annual General Meeting, "Friction Between Solid Bodies," R. Schnurman, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, March 20th.—Literary and Philosophical Society, Newcastle upon Tyne, "The Development and Maintenance of Post-War Naval Machinery," A. F. Smith, 6.15 p.m.

Mon., March 30th.—Mining Institute, Newcastle upon Tyne, "Prevention of Corrosion in Tankers," John Lamb and E. V. Mathias, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Fri., March 27th.—Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1, Full-Day Discussion on "Fatigue."

Tues., March 31st.—4, Hamilton Place, London, W.1, "Experimental Work on Boundary Layer Flow," W. E. Gray, 7 p.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

To-day, March 20th.—Metropolitan Water Board, New River Head, Rosebery Avenue, London, E.C., Annual General Meeting, "Application of Spectro-photometry in the Examination of Waters," R. C. Hoather; "Experience with Rhodocapsa," J. D. Joseph; "Experience with an Experimental Softening Plant," F. P. Hornby, 10 a.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., March 31st.—Manson House, Portland Place, London, W.1, "The Presentation of Control Theory and the Training of Control Engineers," G. L. d'Ombrain, 6.30 p.m.